THE CONDITION OF SOUTH CAROLINA'S ESTUARINE AND COASTAL HABITATS DURING 2009-2010

AN INTERAGENCY ASSESSMENT OF SOUTH CAROLINA'S COASTAL ZONE

TECHNICAL REPORT NO. 107

South Carolina Department of Natural Resources DNR

DHEC PROMOTE PROTECT PROSPER South Carolina Department of Health and Environmental Control

National Oceanic and Atmospheric Administration NOAA U.S. Department of Commerce

U.S. Fish & Wildlife Service Department of the Interior

United States Environmental Protection Agency

The Condition of South Carolina's Estuarine and Coastal Habitats During 2009-2010

Technical Report

Prepared by:

**R.F. Van Dolah, D.M. Sanger, G.H.M. Riekerk,
S.E. Crowe, M.V. Levisen, D.C. Bergquist**

Marine Resources Division
South Carolina Department of Natural Resources
217 Fort Johnson Road
Charleston, SC 29412

D.E. Chestnut and W. McDermott

Bureau of Water
South Carolina Department of Health and Environmental Control
2600 Bull Street
Columbia, SC 29201

M.H. Fulton and E. Wirth

Center for Coastal Environmental Health and Biomolecular Research
National Oceanic and Atmospheric Administration
National Ocean Service Laboratory
219 Fort Johnson Road
Charleston, SC 29412

Technical Report No. 107

2013

SCECAP

South Carolina Estuarine and Coastal Assessment Program

This document should be cited as follows:

R.F. Van Dolah, D.M. Sanger, G.H.M. Riekerk, S.E. Crowe, M.V. Levisen, D.C. Bergquist, D.E. Chestnut, W. McDermott, M.H. Fulton, E. Wirth. 2013. The Condition of South Carolina's Estuarine and Coastal Habitats During 2009-2010: Technical Report. Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 107. 64 p.

Cover photo courtesy of SCDNR Staff

Table of Contents

INTRODUCTION

South Carolina's extensive coastal zone provides a beautiful setting for residents and tourists to enjoy, and supports an abundance of natural resources that can be harvested. The economic impact of coastal tourism alone is valued in excess of 7 billion dollars, and the state's coastal recreational and commercial fisheries contribute in excess of 1 billion and 34 million dollars in economic impact, respectively (*http://asafishing.org/uploads/Sportfishing_in_America_Jan_2008_Revised.pdf*; *http://www.dnr.sc.gov/green/greenreport.pdf*). Most of these fishery resources rely on a variety of sensitive areas that serve as nursery or primary habitat for one or more life stages. Thus, it is critical to protect our coastal habitats from degradation.

As with most coastal states, the population in the coastal counties has been rapidly increasing in recent years, with more than 1.2 million people estimated to be living in South Carolina's eight coastal counties in 2010 (U.S. Census data). This number is expected to increase another 25% by 2030 (South Carolina Budget and Control Board, 2013). The associated expansion of housing, roads, commercial and industrial infrastructure, combined with increased recreational utilization of our coastal waters, will result in increased risk for serious impacts to South Carolina's coastal habitats.

The South Carolina Estuarine and Coastal Assessment Program (SCECAP) was established in 1999 to begin evaluating the overall health of the state's estuarine habitats on a periodic basis using a combination of water quality, sediment quality, and biotic condition measures. This collaborative program involves the South Carolina Department of Natural Resources (SCDNR) and the South Carolina Department of Health and Environmental Control (SCDHEC) as the two lead state agencies, as well as the National Atmospheric and Oceanic Administration National Ocean Service (NOAA/NOS) laboratories located in Charleston (Center for Coastal Environmental Health and Biomolecular Research and the Hollings Marine Laboratory). Shortly after inception of the program, the U.S.

Urban sprawl is one of the primary threats to the quality of South Carolina's estuarine habitats.

Environmental Protection Agency (USEPA) Gulf Ecology Division in Gulf Breeze, FL was strongly involved and utilized SCECAP data as part of their National Condition Assessment (NCA) Program. The USEPA provided funding to this program for the period from 2000-2006 and again for the 2010 sampling period.

SCECAP represents an expansion of ongoing monitoring programs being conducted by both state and federal agencies and ranks among the first in the country to apply a comprehensive, ecosystem-based assessment approach for evaluating coastal habitat condition. While the NCA program provides useful information at the national and regional scale through their National Coastal Condition Reports (NCCR) (*http://water.epa.gov/type/oceb/assessmonitor/nccr/index.cfm*), many of the parameters and thresholds used for the national report are not appropriate for South Carolina. Additionally, the SCECAP initiative collects other data parameters that are not collected by NCA.

There are several specific, yet critical, attributes of the SCECAP initiative that set it apart from other on- going monitoring programs being conducted in

South Carolina by SCDHEC (primarily for water quality) and SCDNR (primarily for fishery stock assessments). These include: (1) sampling sites throughout the estuarine habitats using a random, probability-based approach that complements both agencies' ongoing programs involving fixed station monitoring networks, (2) using integrated measures of environmental and biological condition that provide a more complete evaluation of overall habitat quality, and (3) monitoring tidal creek habitats in addition to the larger open water bodies that have been sampled traditionally by both agencies. This last component is of particular importance since tidal creek habitats serve as important nursery areas for most of the state's economically valuable species and often represent the first point of entry for runoff from upland areas. Thus, tidal creek systems can provide an early indication of anthropogenic stress (Sanger et al., 1999a, b; Lerberg et al., 2000; Van Dolah et al., 2000; 2002; 2004; Holland et al., 2004).

This technical report is part of a series of bi-annual reports describing the status of South Carolina's estuarine habitats. Findings from all reports and the data obtained from those surveys can be obtained from the SCECAP web site *http://www.dnr.sc.gov/marine/scecap/*.

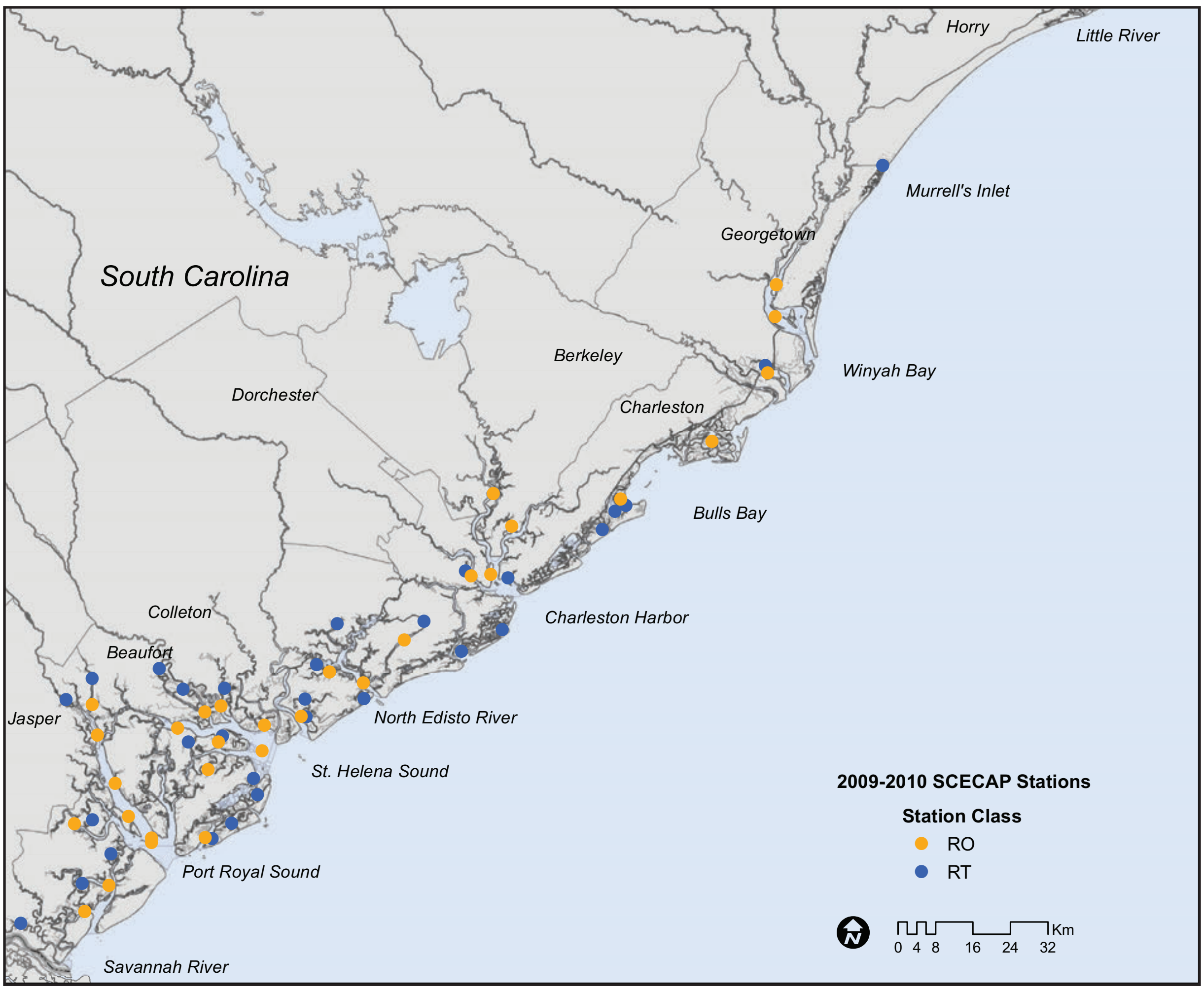


Figure 2.1.1. Locations of stations sampled during 2009 and 2010. RO = open water and RT = tidal creek.

METHODS

The sampling and analytical methods used for SCECAP are fully described in the first SCECAP report (Van Dolah et al., 2002) and can be viewed and downloaded from the SCDNR's SCECAP website (h*ttp://www.dnr.sc.gov/marine/scecap/*). Some of the analytical methods have been modified and are fully described by Bergquist et al. (2009) and in this report. This program uses methods consistent with SCDHEC's water quality monitoring program methods in effect at the time of sample collection (SCDHEC, a-d) and the USEPA's National Coastal Assessment (NCA) program (*http://www.epa.gov/emap/nca/index.html*).

2.1. Sampling Design

Historically, 50-60 stations were sampled annually, but discontinued funding from the NCA program forced a downsizing of the effort beginning in 2007 to a total of 30 stations sampled each year. Sampling sites extend from the Little River Inlet at the South Carolina-North Carolina border to the Savannah River at the South Carolina-Georgia border and from the saltwater-freshwater interface to near the mouth of each estuarine drainage basin. Half of the stations each year are randomly placed in tidal creeks (defined as water bodies < 100 m wide from marsh bank to marsh bank), and the other half are randomly placed in the larger open water bodies that form South Carolina's tidal rivers, bays and sounds. Stations sampled in 2009-2010 are shown in Figure 2.1.1 and listed in Appendix 1. By surface area, approximately 17% of the state's estuarine water represents creek habitat, and the remaining 83% represents the larger open water areas (Van Dolah et al., 2002). Stations within each habitat type are selected using a probability-based, random tessellation, stratified sampling design (Stevens, 1997; Stevens and Olsen, 1999), with new station locations assigned each year.

The primary sampling period for all sampling components is during the summer (July through August). The summer period was selected since it represents a period when some water quality variables may be limiting to biota, and it is a period when many of the fish and crustacean species of concern utilize the estuary for nursery habitat. The same sites (15 tidal creek and 15 open water) are also sampled monthly for the calendar year by SCDHEC for selected water quality measures to meet that agency's mandates (data not reported here). Most measures of water and sediment quality and biological condition are collected within a 2-3 hr time period around low tide. Observations are made at each site to document the presence of litter and to note the proximity of the site to urban/suburban development or industrial development. All data collected go through a rigorous quality assurance process to validate the data sets. A copy of the Quality Assurance Project Plan is maintained at the SCDNR Marine Resources Research Institute. Methods described in the following sections apply to all SCECAP survey periods, past and future.

2.2. Water Quality Measurements

Time-series measurements of temperature, salinity, dissolved oxygen and pH are obtained from the near-bottom waters of each site using YSI Model 6920 multiprobes logging at 15 min intervals for 25 hrs to assess conditions over two full tidal cycles representing both day and night conditions. Both SCDHEC and SCDNR field staff also collect an instantaneous measure of these parameters at several depths in the water column during the primary site visit. Other primary water quality measures that are collected from near-surface waters include total nitrogen (TN; sum of nitrate/nitrite and total Kjeldahl nitrogen (TKN)), total phosphorus (TP), turbidity, chlorophyll a (Chl-a) and fecal coliform bacteria concentrations, and more recently, *Enterococcus* bacteria. Secondary water quality measures that are also collected from near-surface waters include total organic carbon (TOC), total suspended solids (TSS), water clarity based on a Secchi disk measurement, and five-day biochemical oxygen demand (BOD_5). For some survey periods, dissolved nutrient concentrations have been collected, but these measures have generally been discontinued due to budget limitations. Data for the secondary water quality measures are available on the SCECAP web site, but are not described in this report because these measures are not included in the SCECAP Water

Quality Index or have no state water quality standards.

All water quality samples are collected by inserting pre-cleaned water bottles to a depth of 0.3 m and then filling the bottle directly at that depth. Water samples collected for dissolved nutrient quantification are filtered in the field through a 0.45 µm pore cellulose acetate filter. The bottles are then stored on ice until they are returned to the laboratory for further processing. Total nutrients, TOC, total alkalinity, TSS, turbidity, BOD_5, Chl-a and bacteria samples are processed by SCDHEC using the standardized procedures in effect at the time of sample collection or analysis (SCDHEC b,c,d).

2.3. Sediment Quality Measurements

At least six bottom sediment samples are collected at each station using a stainless steel 0.04 m^2 Young grab deployed from an anchored boat that is repositioned between samples. The surficial sediments (upper 2 cm) of four or more grab samples are homogenized on-site and placed in pre-cleaned containers for analysis of silt and clay content, total organic carbon (TOC), total ammonia nitrogen (TAN), contaminants, and sediment toxicity. All sediment samples are kept on ice while in the field and then stored either at 4^oC (toxicity, porewater) or frozen (contaminants, silt and clay content, TOC) until analyzed. Particle size analyses are performed using a modification of the pipette method described by Plumb (1981). Porewater ammonia is measured using a Hach Model 700 colorimeter, and TOC is measured on a Perkin Elmer Model 2400 CHNS Analyzer. Contaminants measured in the sediments include 28 metals, 25 polycyclic aromatic hydrocarbons (PAHs), 79 polychlorinated biphenyls (PCBs), 13 polybrominated diphenyl ethers (PBDEs) and 21 pesticides. All contaminants are analyzed by the NOAA/NOS Center for Coastal Environmental Health and Biomolecular Research (CCEHBR) using procedures similar to those described by Krahn et al. (1988), Fortner et al. (1996), Kucklick et al. (1997) and Long et al. (1997). The sediment contaminant concentrations are simplified into an Effects Range Median Quotient (ERM-Q) which provides a convenient measure of overall contamination based on 24 compounds for which there are biological effects guidelines (Long and Morgan, 1990; Long et al., 1995, 1997; Hyland et al., 1999). Long term monitoring programs such as SCECAP must find a balance between using the same methods and measures for consistency across time, and incorporating new methods and measures as they are developed and proven.

SCDHEC staff sampling water quality at a SCECAP station.

Sediment toxicity is measured using two bioassays: 1) the Microtox® solid-phase assay using a photoluminescent bacterium, *Vibrio fischeri*, and protocols described by the Microbics Corporation (1992), and 2) a 7-day juvenile clam growth assay using *Mercenaria mercenaria* and protocols described by Ringwood and Keppler (1998). Toxicity in the Microtox® assay is based on criteria described by Ringwood et al. (1997; criterion #6: toxic when scores of < 0.5 if silt/clay < 20% and scores of < 0.2 if silt/clay > 20%). For the clam assay, sediments are considered toxic if growth (change in dry weight) is < 80% of that observed in control sediments and there was a statistically significant difference ($p < 0.05$). In some survey periods, a 10-day whole sediment amphipod assay was performed as a third toxicity measure. The amphipod assay has generally proven to be very insensitive for South Carolina sediments and has not been retained as part of the suite of toxicity measures for the SCECAP program.

2.4. Biological Condition Measurements

Two of the samples collected by Young grab are washed through a 0.5 mm sieve to collect the benthic invertebrate fauna, which are then preserved in a 10% buffered formalin/seawater solution containing Rose Bengal stain. All organisms from the two grabs are identified to the species level or to the lowest practical taxonomic level if the specimen is too damaged or immature for accurate identification. A reference collection of all benthic species collected for this program is being maintained at the SCDNR Marine Resources Research Institute. The benthic data are incorporated into a Benthic Index of Biotic Integrity (B-IBI; Van Dolah et al., 1999).

Deploying a grab sampler to collect a sediment sample for chemistry and benthic analysis.

Fish and large crustaceans are collected by trawl at each site following benthic sampling to evaluate near-bottom community composition. Two replicate tows are made sequentially at each site using a 4-seam trawl (5.5 m foot rope, 4.6 m head rope and 1.9 cm bar mesh throughout). Trawl tow lengths are standardized to 0.5 km for open water sites and 0.25 km for creek sites. Organisms captured are identified to the species level, counted, and checked for gross pathologies, deformities, or external parasites. Up to 25 individuals of each species are measured to the nearest centimeter. Mean abundance of finfish and crustaceans are corrected for the total area swept by the two trawls using the formula described by Krebs (1972). Tissue contaminant samples are no longer collected by SCECAP due to cost constraints. Contaminant samples were collected for the USEPA in 2010, but the data are not reported here.

2.5. Integrated Indices of Estuarine Habitat Condition

One of the primary objectives of SCECAP is to develop integrated measures of estuarine condition that synthesize the program's large and complex environmental datasets. Such measures provide natural resource managers and the general public with simplified statements about the status and trends of the condition of South Carolina's coastal zone. Similar approaches have been developed by federal agencies for their National Coastal Condition Reports (USEPA, 2001; 2004; 2006) as well as by a few states and other entities using a variety of approaches (Carlton et al., 1998; Chesapeake Bay Foundation, 2007; Partridge, 2007).

SCECAP computes four integrated indices describing different components of the estuarine ecosystem: water quality, sediment quality, biological condition and an overall Habitat Quality Index (Table 2.5.1). The Water Quality Index combines four individual measures, the Sediment Quality Index combines three measures, and the Biological Condition Index includes only the B-IBI (see later sections and Bergquist et al., 2011 for details). These three indices are then combined into a single integrated Habitat Quality Index. The integrated indices improve public communication

Table 2.5.1. Individual measures comprising the integrated Water Quality, Sediment Quality, and Biological Condition indices.

Water Quality Index	Sediment Quality Index	Biological Condition Index
Dissolved Oxygen	Contaminants (ERM-Q)	B-IBI
Fecal Coliform Bacteria	Toxicity	
pH	Total Organic Carbon	
Eutrophic Index		
Total Nitrogen		
Total Phosphorus		
Chlorophyll a		

of multi-variable environmental data and provide a more reliable tool than individual measures (such as DO, pH, etc.) for assessing estuarine condition. For example, one location may have apparently degraded DO but normal values for all other measures of water quality, while a second location has degraded levels for the majority of water quality measures. If DO were the only measure of water quality used, both locations would be classified as having degraded condition with no basis for distinguishing between the two locations. However, an index that integrates multiple measures would likely not classify the first location as degraded and yet detect the relatively greater degradation at the second location.

Current methods for calculating the four integrated indices are described in detail in the 2005-2006 SCECAP report (Bergquist et al., 2009). Broadly, each individual measure taken at a sampled station and used to calculate the integrated indices is given a score of "good," "fair," or "poor." In the various graphics and tables of this report, poor conditions are indicated by red, fair by yellow and good by green. Thresholds for defining conditions as good, fair, or poor are based on state water quality standards (SCDHEC, 2008), published findings (Hyland et al., 1999 for ERM-Q; Van Dolah et al., 1999 for benthic condition; Ringwood et al., 1997, and Ringwood and Keppler, 1998 for toxicity measures), or percentiles of a historical database for the state based on SCECAP measurements collected from 1999-2006. The thresholds used in this report are listed in Appendix 2. These scores are given a numerical ranking (good as highest (5), fair as intermediate (3), poor as lowest (0)) and averaged into an integrated index score (described in general terms in Van Dolah et al. (2004)). The integrated indices are likewise given a score of good, fair, or poor using methods described in Van Dolah et al. (2004). It is important to note that as new information has become available, the calculation methodology used by SCECAP has been modified. Modifications include changes in the individual measures used in the integrated indices, individual threshold values, and scoring processes. While these changes often do not result in very large changes in data interpretation, the results presented in this report may not match exactly those in previous reports. However, the current report does reflect the updated approach applied to all measures and previous survey periods.

2.6. The Presence of Litter

Litter is one of the more visible signs of habitat degradation. While the incidence of litter is not used in the overall habitat quality index, the presence of litter in the trawl or on the banks for 250 meters on each side of the station was recorded.

2.7. Data Analysis

Use of the probability-based sampling design provides an opportunity to statistically estimate, with confidence limits, the proportion of South Carolina's estuarine habitat classified as being in good, fair, or poor condition. These estimates are obtained through analysis of the cumulative distribution function (CDF) using procedures described by Diaz-Ramos et al. (1996) and using programs developed within the R statistical package. The percent of the state's overall estuarine habitat scoring as good, fair, or poor for individual measures and for each of the indices is calculated after weighting the analysis by the proportion of the state's estuarine habitat represented by tidal creek (17%) and open water (83%) habitat. In the past, SCECAP used continuous data in these analyses when possible, but this methodology was modified to use only categorical scores in order to improve 1) consistency with reporting by the SCDHEC Ambient Water Quality Monitoring Network, and 2) calculation of the 95% confidence limit for each estimate. Additionally, the difference in scores between tidal creek and open water habitats is now well-established in South Carolina (Van Dolah et al., 2002; 2004; 2006; Bergquist et al., 2009; 2011; Appendix 2). For brevity, graphical summaries in this report are limited to overall estuarine habitat condition (tidal creek and open water combined).

RESULTS AND DISCUSSION

3.1. Water Quality

SCECAP collects a wide variety of water quality parameters each year as part of the overall investigation of estuarine habitat quality. Poor water quality measures, if observed repeatedly in a drainage system, can provide an early warning of impaired habitat, especially related to nutrient enrichment and bacterial problems. Measurements obtained from the 2009-2010 survey can be found at (*http://www.dnr.sc.gov/marine/scecap/*) for all of the parameters collected. Six of those parameters are considered to be the most relevant with respect to biotic health and human uses, and have been incorporated into a Water Quality Index (WQI) developed for SCECAP. These include: 1) dissolved oxygen (DO), which is critical to healthy biological communities and can reflect organic pollution; 2) pH, which measures the acidity of a water body and can indicate the influence of various kinds of human input, such as atmospheric deposition from industry and vehicle emissions, runoff from land sources, etc.; 3) fecal coliform bacteria, which are an indicator of potential human pathogens and 4) a combined measure of total nitrogen (TN), total phosphorus (TP) and chlorophyll-a (Chl-a), which provides a composite measure of the potential for a water body to be experiencing nutrient enrichment and/or associated algal blooms. These latter three measures (TN, TP and Chl-a) are combined into a Eutrophic Index, which equals one quarter of the weight of the overall WQI.

The 2009-2010 survey documented the highest average WQI since the inception of the program, with 94% of the state's estuarine habitat coding as good water quality, 5% coding as fair, and only 1% coding as poor (Figures 3.1.1, 3.1.2). None of the four component measures of the WQI had more than 3% of the coastal habitat rating as poor. As in all previous survey periods, tidal creek habitat showed an overall lower water quality rating compared to open water habitats (Table 3.1.1, Appendix 2). The continuous increase in good water quality that the program has observed since the 2003-2004 survey period is most likely attributable to drought conditions, with average rainfall in the coastal counties during July and August, 2009-2010 being the lowest observed since the inception of the program (Figure 3.1.3a). A clear relationship continues to be established demonstrating that the percentage of good WQI scores in the coastal waters is strongly related with reduced rainfall (Figure 3.1.3b). Lower rainfall results in less runoff from the land which in turn results in less nutrient and bacterial input into our coastal waters.

The distribution of stations with good, fair or poor WQI scores are shown in Figures 3.1.4a, 3.1.5a, and 3.1.6a for the 2009-2010 survey period. Only two sites had poor water quality and both were located in Beaufort County in Wimbee Creek and Main Creek (Figure 3.1.6a). Main Creek had not been sampled in previous surveys, but several stations located closer to the mouth of Wimbee Creek have only coded as being in fair condition in past surveys (Figure 3.1.6b). Only four tidal creek sites and one open water site had fair WQI scores.

When considering all years (1999-2010), portions of the state with a relatively high incidence of fair to poor water quality remain concentrated in Winyah Bay, the Ashley River, drainages in the vicinity of the Dawhoo River, and the Ashepoo and Combahee Rivers and associated drainage basins, New River, and portions of the Wright River (Figures 3.1.4a, 3.1.5a, 3.1.6a). Special studies have been initiated to resolve causes of poor water quality in the ACE Basin (Ashepoo, Combahee, Edistor Rivers), but similar studies have not been initiated elsewhere due to funding limitations.

South Carolina's wildlife need good water quality.

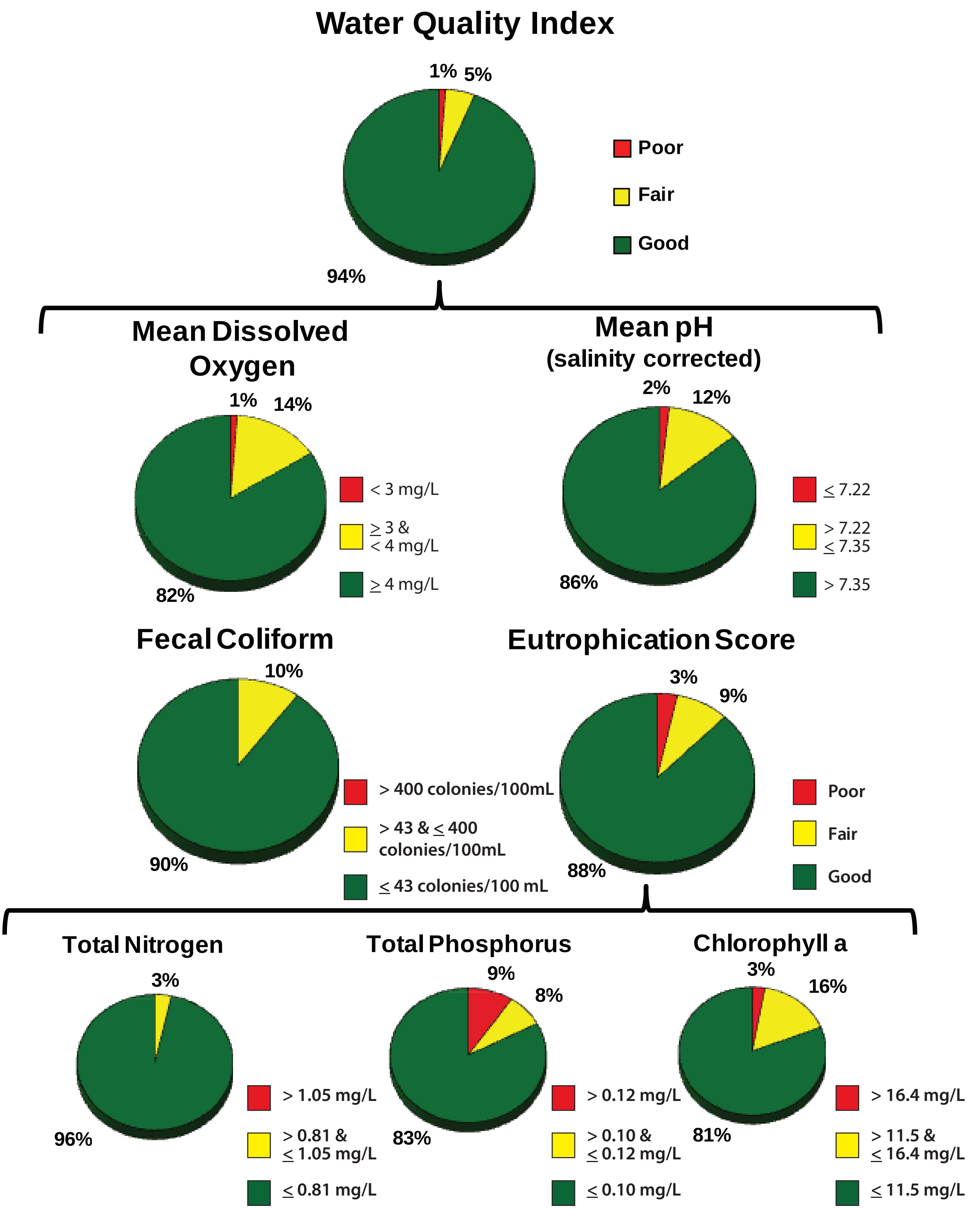


Figure 3.1.1. Percentage of the state's estuarine habitat combined that scored as good, fair or poor for the Water Quality Index and the component parameters that comprise the index. Percentage is based on data obtained from 30 stations for each habitat. Percentage pie values that don't total to 100% indicate a portion of state waters that could not be coded due to missing samples.

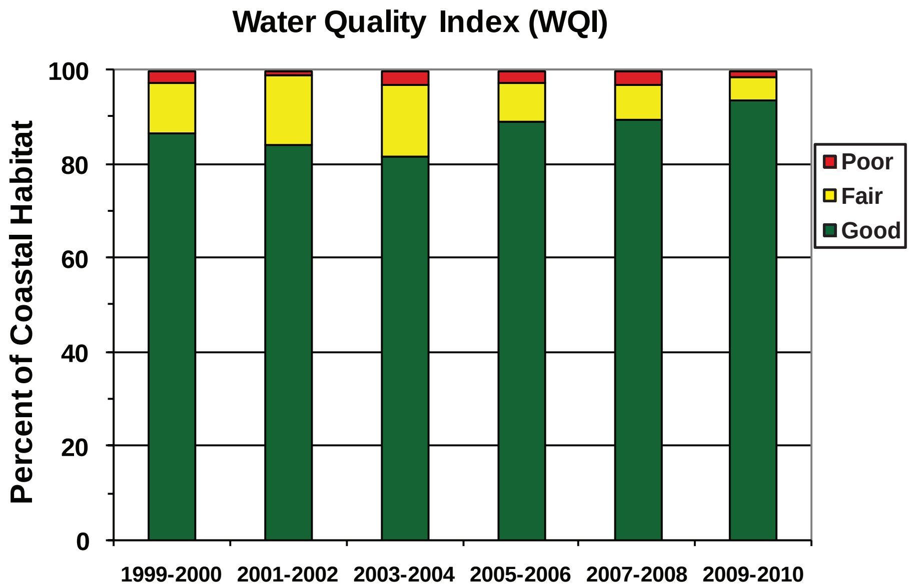


Figure 3.1.2 . Water Quality Index values observed by survey period for all coastal waters.

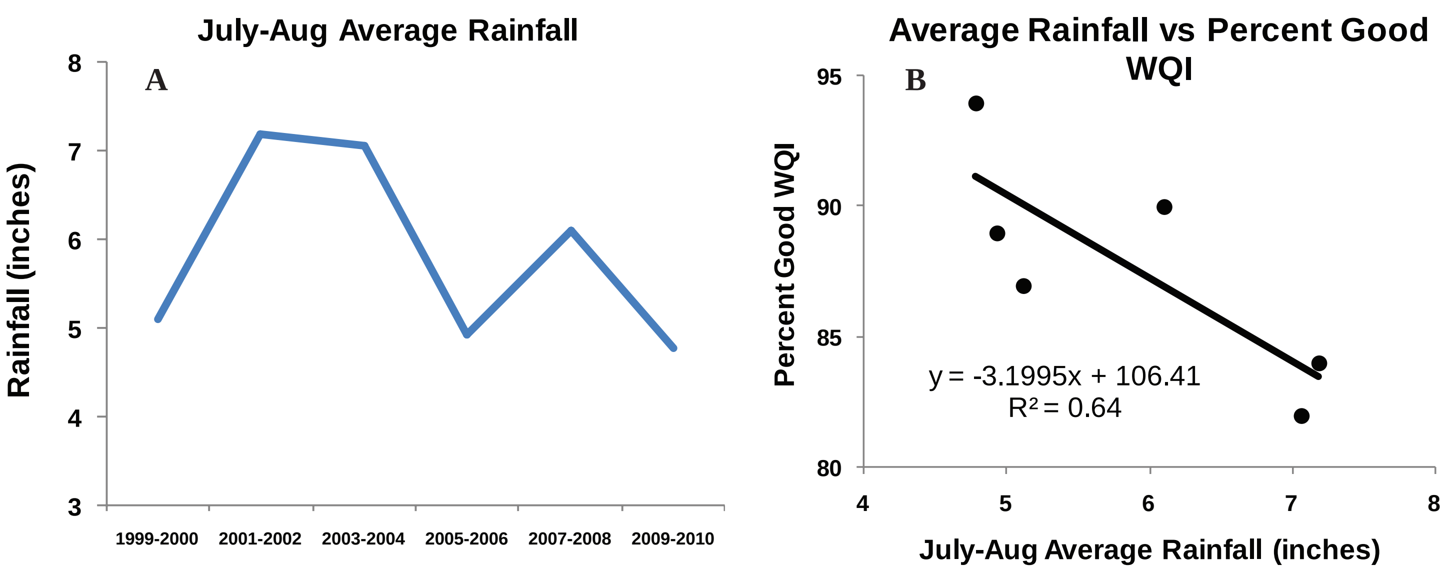
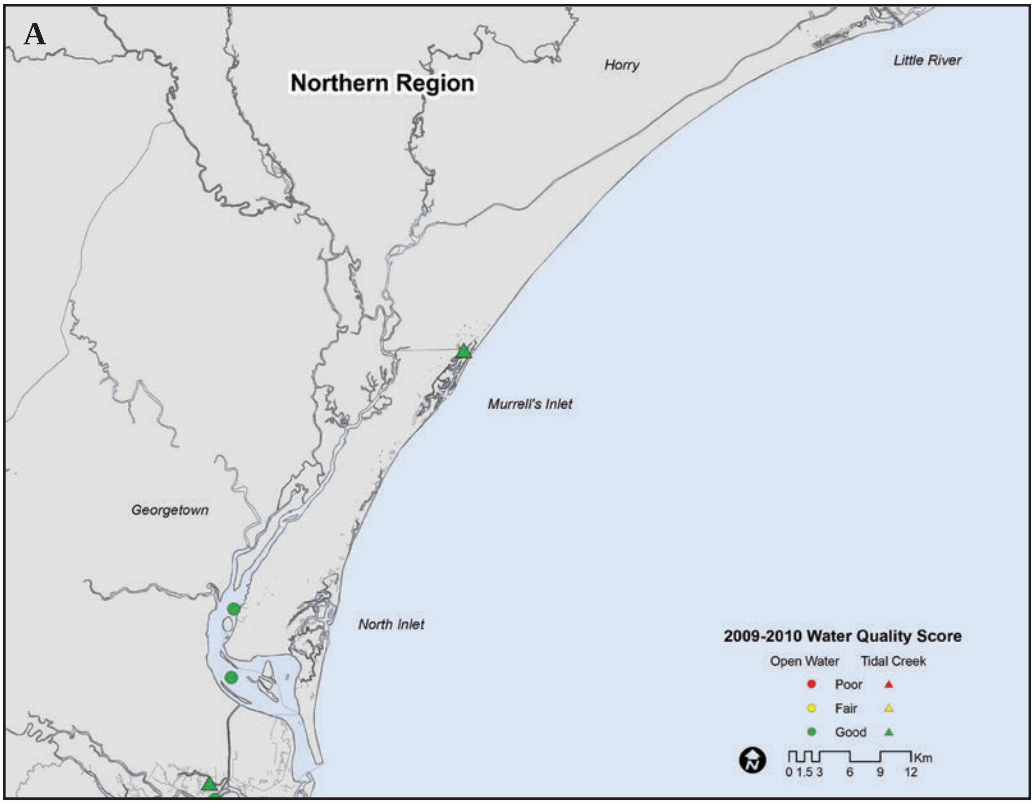


Figure 3.1.3. The average rainfall observed during July and August for each survey period (A) and the percent good Water Quality Index (WQI) versus the average rainfall (B). The average rainfall is for Beaufort, Colleton, Charleston, and Georgetown Counties. Data downloaded from the Southeast Regional Climate Center (http://sercc.com).

Table 3.1.1. Summary of mean water quality measures observed in tidal creek and open water habitats during each year of the SCECAP survey. Blue highlight indicates those measures included in the Water Quality Index.

		Year											
Measure	**Habitat**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
WQI	Open	4.56	4.83	4.64	4.73	4.57	4.66	4.77	4.80	4.78	4.85	4.90	4.65
	Creek	4.02	3.86	4.28	4.40	4.25	4.20	4.38	4.35	4.45	4.10	4.65	3.90
Dissolved Oxygen (mg/L)	Open	4.86	5.01	4.96	5.10	4.97	5.41	5.13	5.11	5.49	5.62	5.54	5.05
	Creek	4.00	4.12	4.45	4.51	4.58	5.10	4.12	4.33	4.53	4.50	4.41	4.12
pH	Open	7.58	7.53	7.67	7.71	7.39	7.75	7.59	7.68	7.68	7.68	7.63	7.58
	Creek	7.52	7.43	7.56	7.53	7.31	7.36	7.30	7.48	7.43	7.49	7.49	7.37
Total Nitrogen (mg/L)	Open	0.51	0.58	0.66	0.52	0.84	0.52	0.57	0.20	0.26	0.52	0.57	0.25
	Creek	0.69	0.75	0.72	0.58	0.72	0.64	0.67	0.20	0.32	0.65	0.62	0.32
Total Phosphorus (mg/L)	Open	0.08	0.06	0.06	0.05	0.06	0.08	0.08	0.07	0.06	0.05	0.07	0.09
	Creek	0.09	0.10	0.09	0.06	0.09	0.12	0.08	0.07	0.06	0.09	0.09	0.09
Chlorophyll a (ug/L)	Open	10.29	9.08	10.06	10.14	6.86	8.37	7.72	7.44	11.00	9.24	7.18	9.23
	Creek	12.58	12.54	10.84	9.74	11.59	12.02	8.00	10.11	10.89	8.91	7.85	12.13
Fecal Coliform (col/100mL)	Open	46.52	10.93	14.27	9.20	25.30	16.73	11.68	23.52	16.80	13.13	18.67	9.93
	Creek	29.69	54.53	34.58	25.47	73.90	86.53	29.40	64.83	14.20	31.73	5.13	26.80
Temperature (C)	Open	30.20	29.44	29.48	29.10	28.47	29.15	29.96	29.68	29.76	28.99	28.53	30.82
	Creek	30.07	29.79	29.54	29.03	28.96	29.64	29.92	30.18	30.26	29.91	29.86	31.25
Salinity (ppt)	Open	26.22	28.13	28.16	31.02	19.93	28.45	25.95	31.08	30.31	31.34	26.40	30.79
	Creek	31.06	31.47	29.41	32.13	20.76	26.18	23.22	32.27	29.27	31.96	30.90	29.72
BOD_5	Open	2.28	0.92	0.66	0.16	0.00	0.07	0.11	0.10	0.31	0.31	na	na
	Creek	2.63	1.12	0.64	0.62	0.75	0.82	0.49	0.37	0.58	0.52	na	na
Total Suspended Solids	Open	na	na	28.18	42.03	20.25	21.60	35.26	33.38	61.05	45.07	14.64	19.83
	Creek	na	na	52.60	54.15	37.52	38.23	49.82	37.81	44.07	71.47	23.40	38.87
Turbidity	Open	15.81	12.56	16.38	13.49	13.89	10.96	14.50	11.10	14.93	14.09	7.80	11.40
	Creek	22.40	19.81	29.47	15.97	25.48	18.46	19.33	14.42	19.85	21.30	12.19	18.59
Total Organic Carbon	Open	3.98	4.10	5.62	4.96	11.57	6.46	8.28	6.55	6.95	7.30	5.62	na
	Creek	2.61	4.25	5.05	5.77	15.69	9.55	10.00	8.15	7.97	6.90	6.06	na
Alkalinity	Open	97.48	96.69	97.60	106.00	75.07	98.83	93.64	107.83	108.40	75.50	94.47	106.80
	Creek	115.59	115.38	108.24	111.83	86.93	100.33	92.92	113.88	106.53	140.00	118.13	108.40



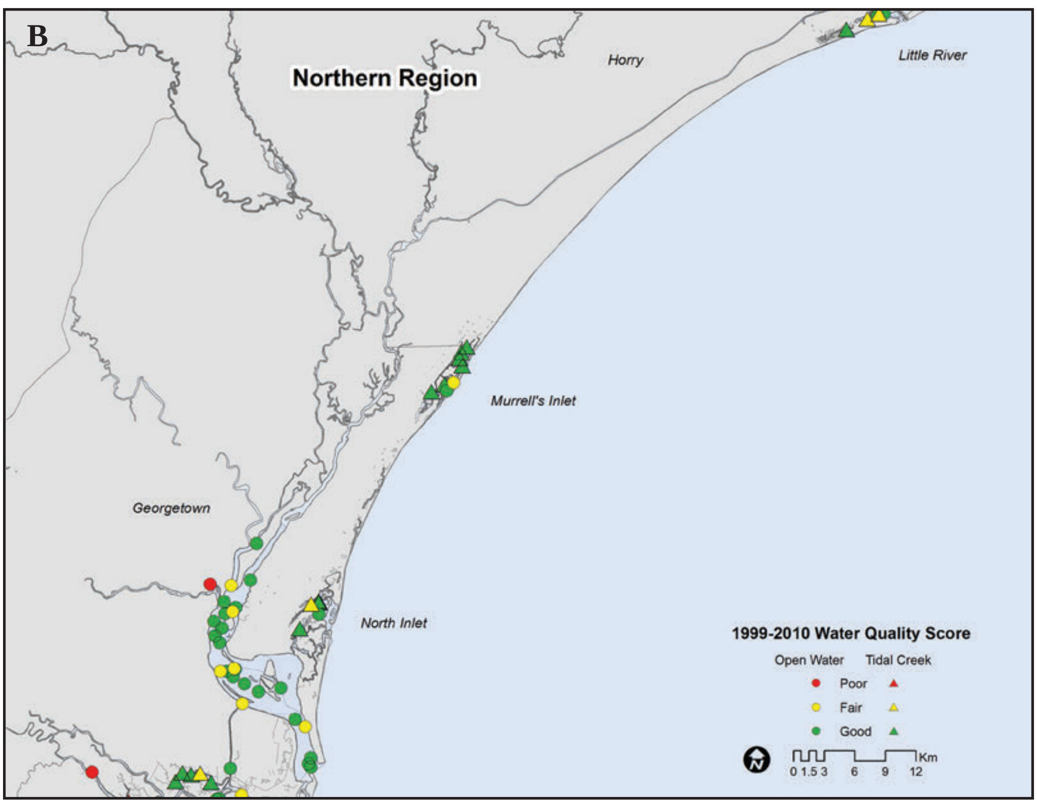
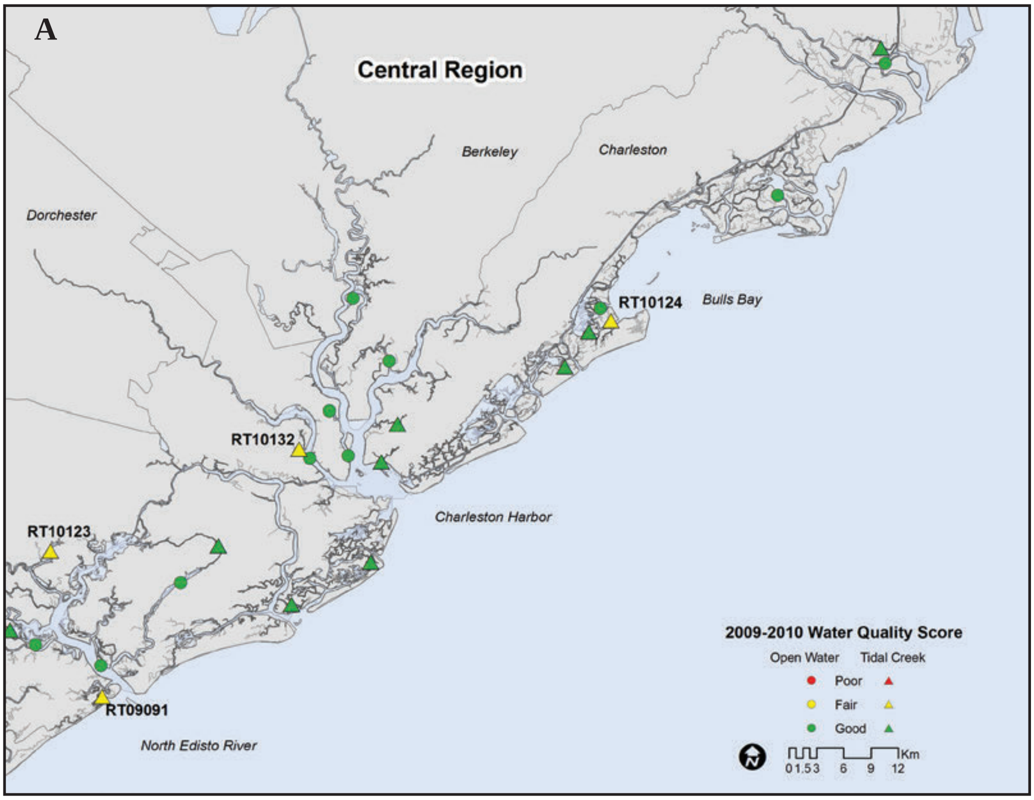


Figure 3.1.4. Distribution of stations with good, fair or poor scores for the Water Quality Index during the 2009-2010 (A) and 1999-2010 (B) periods for the northern region of South Carolina.



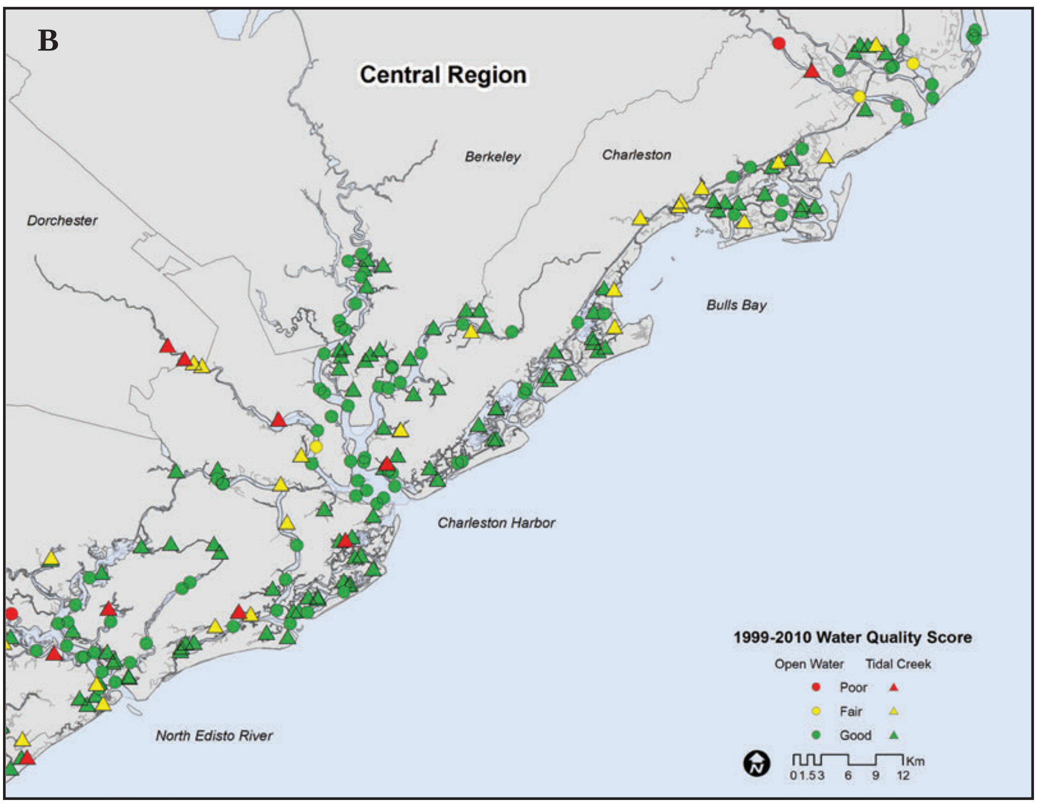
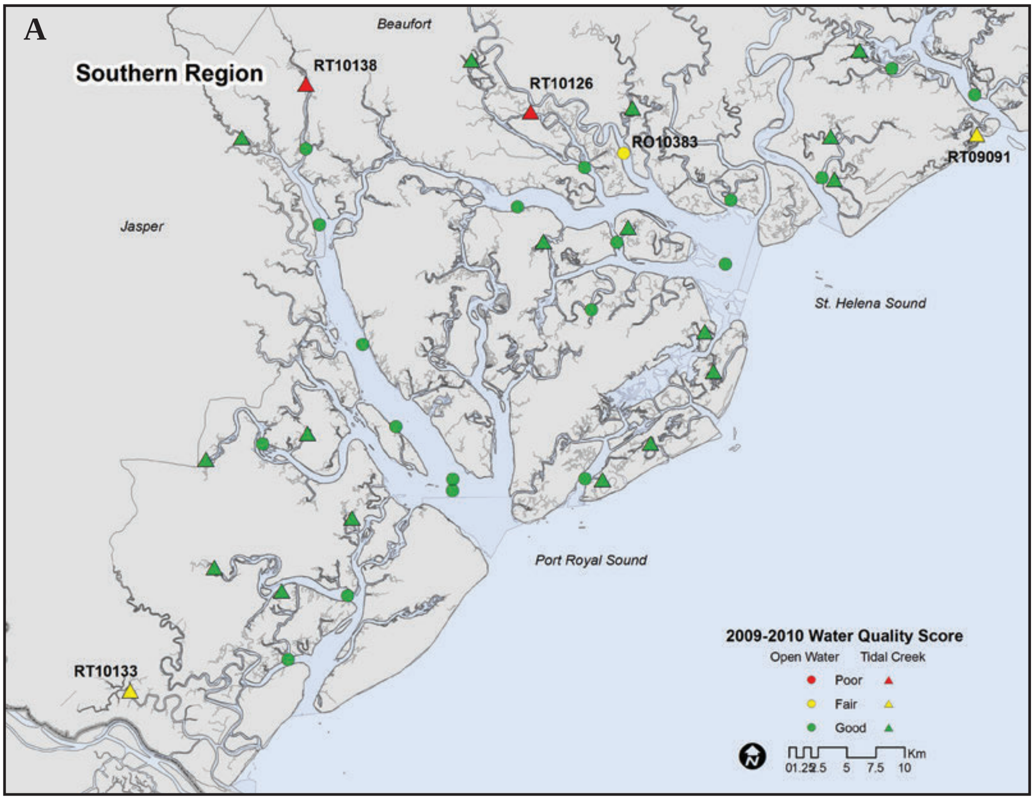


Figure 3.1.5. Distribution of stations with good, fair or poor scores for the Water Quality Index during the 2009-2010 (A) and 1999-2010 (B) periods for the central region of South Carolina.



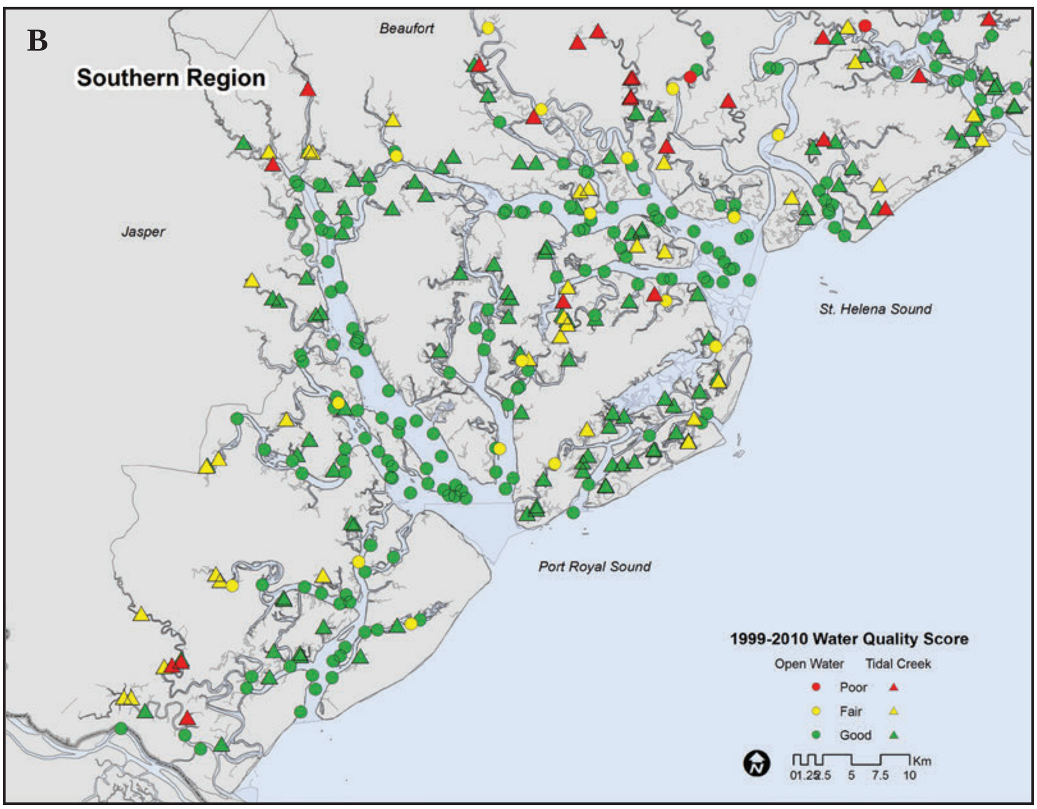


Figure 3.1.6. Distribution of stations with good, fair or poor scores for the Water Quality Index during the 2009-2010 (A) and 1999-2010 (B) periods for the southern region of South Carolina.

3.2. Sediment Quality

Sediment quality measurements remain an essential component of our overall estuarine habitat quality assessment because sediments: 1) support invertebrate communities that form the base of the food web for many other species of concern, 2) exchange nutrients and gases with overlying water in support of overall estuarine function, and 3) serve as a sink for contaminants which can accumulate over time, providing a better measure of long-term exposure to contaminants in an area. Although many sediment quality measures are collected by SCECAP, the three component measures of the Sediment Quality Index (SQI) are considered to be the most indicative of sediment quality. These include: 1) a combined measure of 24 organic and inorganic contaminants that have published biological effects thresholds (ERM-Q; Long et al., 1997; Hyland et al., 1999; 2003), 2) a measure of sediment toxicity based on 2 bioassays that indicates whether contaminants are present at concentrations that have adverse biological effects, and 3) total organic carbon (TOC), which can have several adverse effects on bottom-dwelling biota and provides a good predictor of benthic community condition (Hyland et al., 2005).

The percentage of the state's estuarine habitat that scored as good, fair, or poor using the Sediment Quality Index (SQI) has remained similar for the past three survey periods (2005-2006, 2007-2008, 2009-2010) with 83% of South Carolina's estuarine habitat having good sediment quality for each of those surveys. In the current survey, 8% of the area coded as fair and 9% coded as poor (Figures 3.2.1, 3.2.2). In contrast to previous years, tidal creek habitat was not very different from open water habitat with respect to the percentage of habitat that scored as good, fair, or poor (Appendix 2).

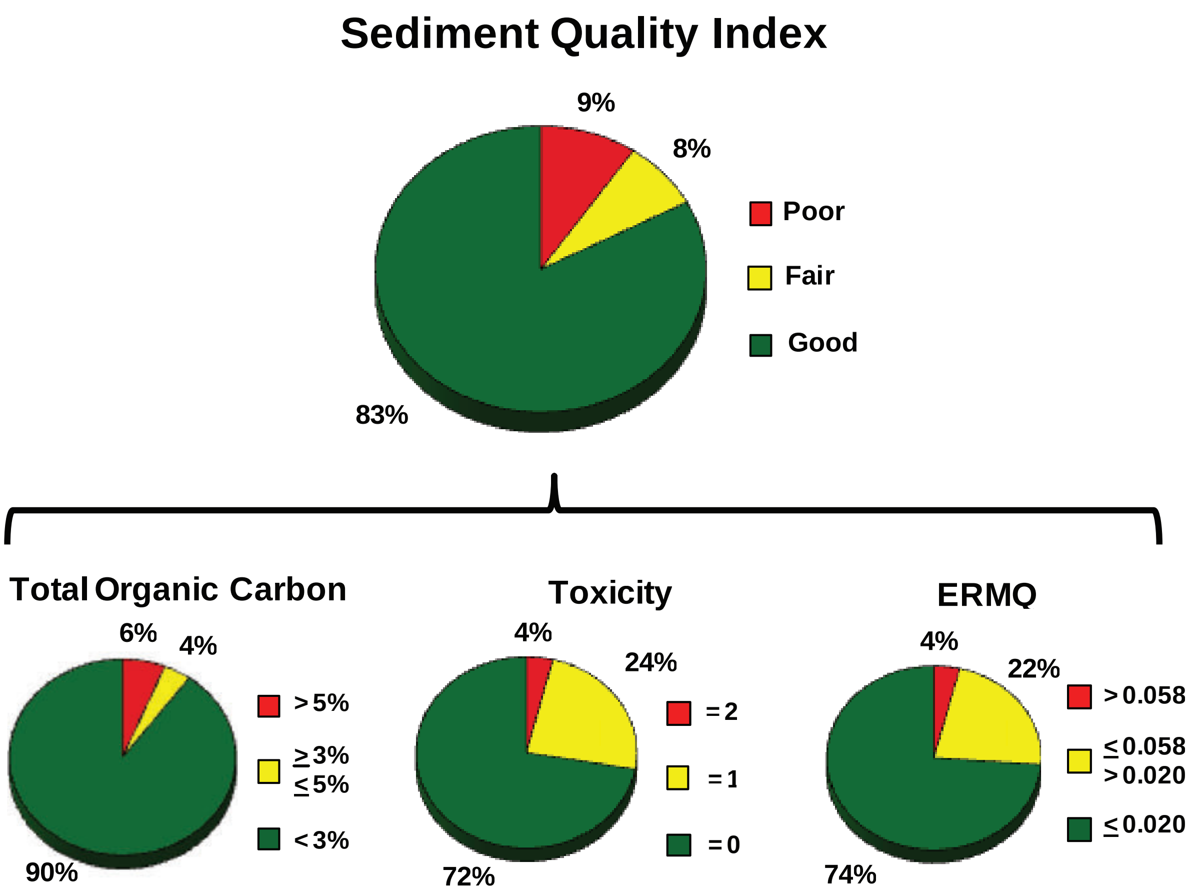


Figure 3.2.1. Percentage of the state's estuarine habitat that scored as good, fair, or poor for the Sediment Quality Index and it's component measures during 2009-2010.

Among the three SQI component measures, both sediment contaminant (ERM-Q) and toxicity measures showed higher percentages of the state's waters in only fair or poor condition (26% and 28% , respectively) whereas total organic carbon (TOC) was considered fair or poor for only 10% of the habitat. Since the overall SQI indicated that only 8% of the state's estuarine habitat was in fair condition, most of the sites sampled during this survey did not have both elevated contaminants and toxicity in the sediments (Appendix 3). Only 4% of the states habitat coded as poor for both contaminant concentrations and toxicity and 6% of the habitat coded as poor for total organic carbon. The continued low percentage of habitat with fair or poor sediment quality is most likely due to the continued drought conditions based on the strong relationship demonstrated in Figure 3.2.3. Once the state's rainfall conditions return to normal or higher than normal conditions, we may observe a significant increase in sediments that are only fair or poor in quality.

Stations which contained poor sediment quality in the 2009-2010 survey included three open water and four tidal creek sites (Figures 3.2.4a, 3.2.5a, 3.2.6a; Appendix 3). The open water sites were located in the North Santee, Cooper, and Ashley Rivers, all areas where poor sediment quality has been observed in previous surveys (Figures 3.2.4b, 3.2.5b, 3.2.6b). The poor tidal creek sites were located in the North Santee River, Shem Creek in Charleston Harbor, Williman Creek in the ACE Basin, and the headwaters of the Broad River. With the exception of the latter site, all of these drainages have had sites with poor SQI scores in the past. When all survey periods are considered collectively, sites with only fair SQI scores were observed in Winyah Bay, the Cape Romain area, a tidal creek in the Ashley River, two sites in the ACE Basin, and one station in the upper portion of the Wright River (Figures 3.2.4b, 3.2.5b, 3.2.6b).

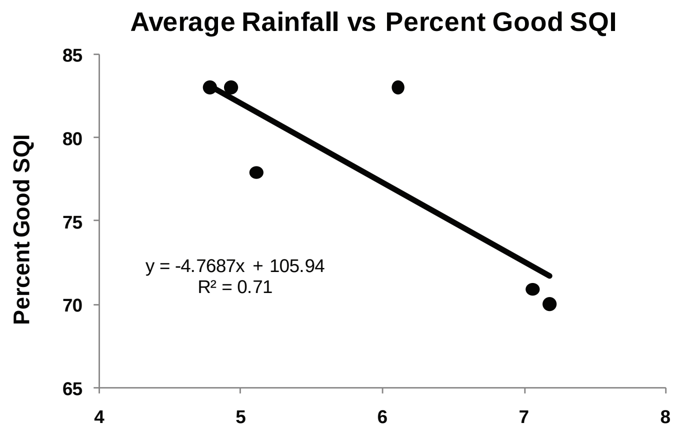


Figure 3.2.3. The percent good Sediment Quality Index (SQI) versus the average rainfall for each of the survey periods.

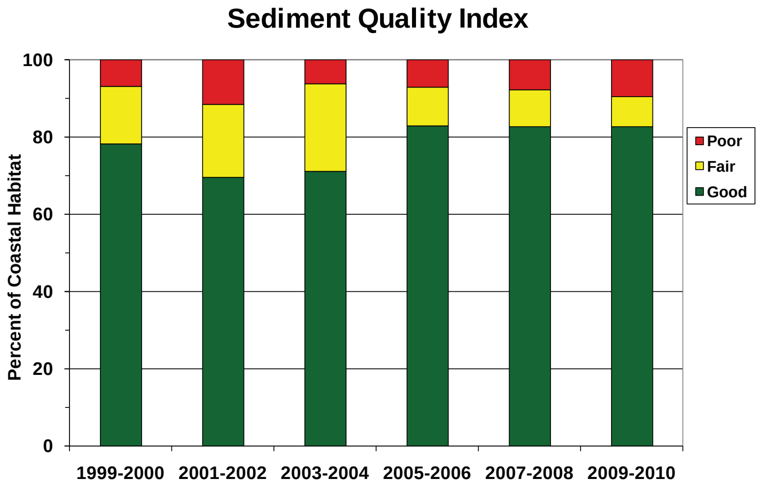


Figure 3.2.2. Sediment Quality Index Scores by survey period for all estuarine habitat.

The Ashley River site (RO09363) had the highest contaminant concentration ever observed by SCECAP (ERMQ = 3.033). This is substantially higher than the next highest ERMQ score (0.163 at RO00056 a station adjacent to a superfund site). Staff at NOAA's Hollings Marine Laboratory have initiated a special study at this location in the river to evaluate the distribution and potential source of the contaminants.

Our tidal creeks serve as an early warning sentinel habitat. While the elevated contaminant concentrations in our state's tidal creeks are not great relative to known bioeffects levels, continued degradation of these habitats is likely to occur with increasing coastal development.

Suburban and urban development, including roads and parking lots, contribute to the contaminants reaching our creeks and wetlands.

Table 3.2.1. Summary of mean sediment quality measures observed in tidal creek and open water habitats during each year of the SCECAP survey. Blue highlight indicates those measures included in the Sediment Quality Index.

		Year											
Measure	**Habitat**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
SQI	Open	4.44	4.36	4.23	4.17	4.37	4.21	4.37	4.56	4.49	4.58	4.33	4.56
	Creek	4.42	4.27	3.69	4.12	4.14	4.24	3.95	4.52	3.87	4.36	4.73	4.04
Total Organic Carbon (%)	Open	0.86	0.63	0.94	0.84	0.74	0.88	0.70	0.77	0.79	0.70	1.15	0.62
	Creek	1.08	1.33	1.30	1.39	1.30	1.12	1.48	1.03	1.71	1.06	1.08	1.35
ERM-Q	Open	0.013	0.013	0.013	0.017	0.014	0.015	0.013	0.017	0.013	0.014	0.21	0.02
	Creek	0.015	0.014	0.017	0.015	0.018	0.016	0.018	0.013	0.022	0.015	0.01	0.03
Sediment Bioassays	Open	0.48	0.67	0.70	0.70	0.53	0.70	0.60	0.20	0.40	0.33	0.27	0.33
	Creek	0.52	0.67	1.16	0.70	0.70	0.70	0.84	0.36	0.73	0.53	0.27	0.53
Silt & Clay (%)	Open	22.3	15.1	23.0	20.5	15.4	24.2	17.7	17.9	22.7	18.7	26.79	15.84
	Creek	32.0	31.8	30.3	30.9	34.3	26.0	37.4	21.0	40.7	23.4	27.64	26.94
Total Ammonia Nitrogen	Open	2.62	2.91	2.51	3.64	3.22	4.13	1.95	2.09	1.69	3.44	2.84	1.96
	Creek	2.79	3.06	3.46	2.75	4.74	2.17	2.48	2.16	2.04	2.23	2.75	3.25

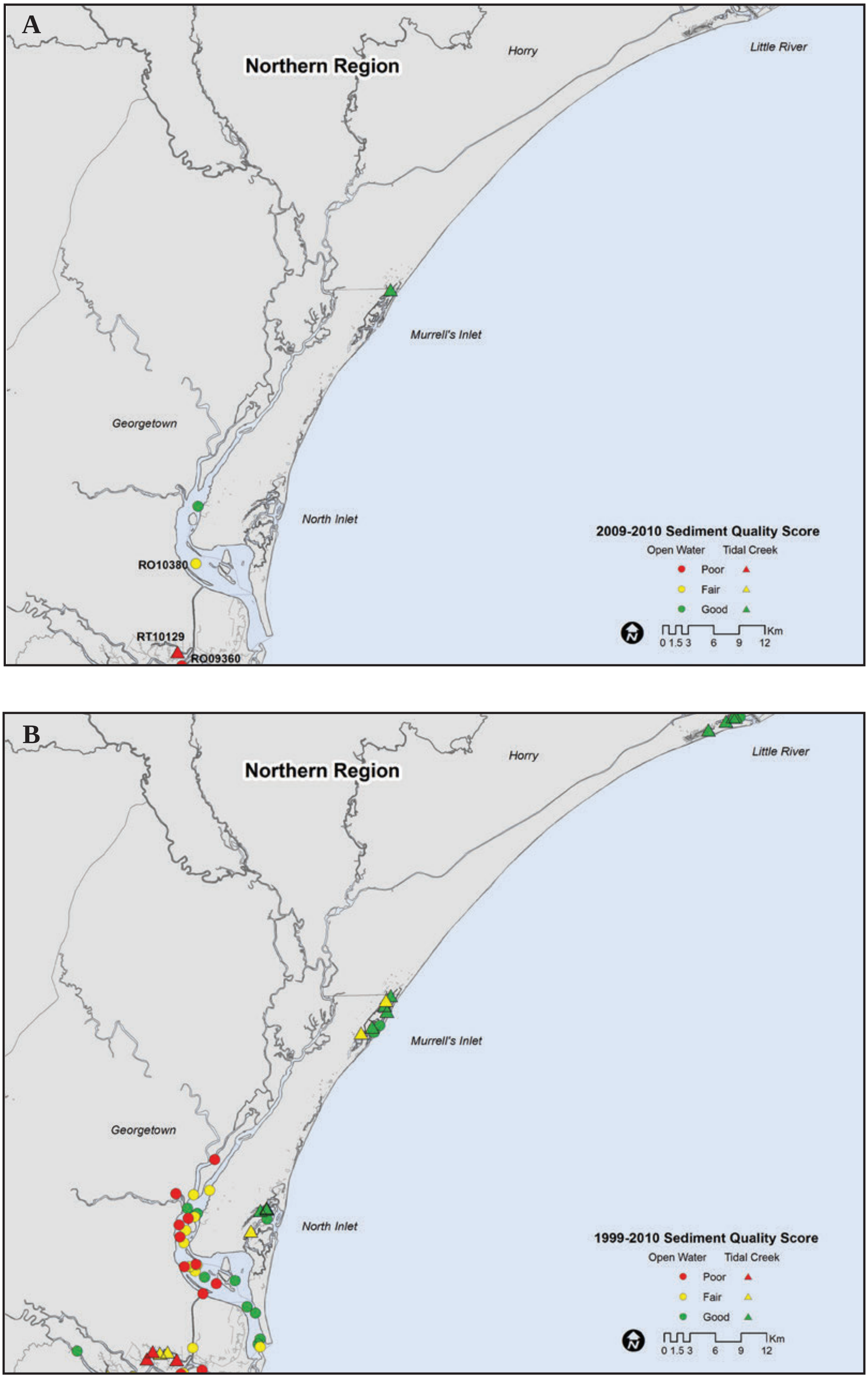


Figure 3.2.4. Distribution of stations with good, fair or poor scores for the Sediment Quality Index during the 2009-2010 (A) and 1999-2010 (B) periods for the northern region of South Carolina.

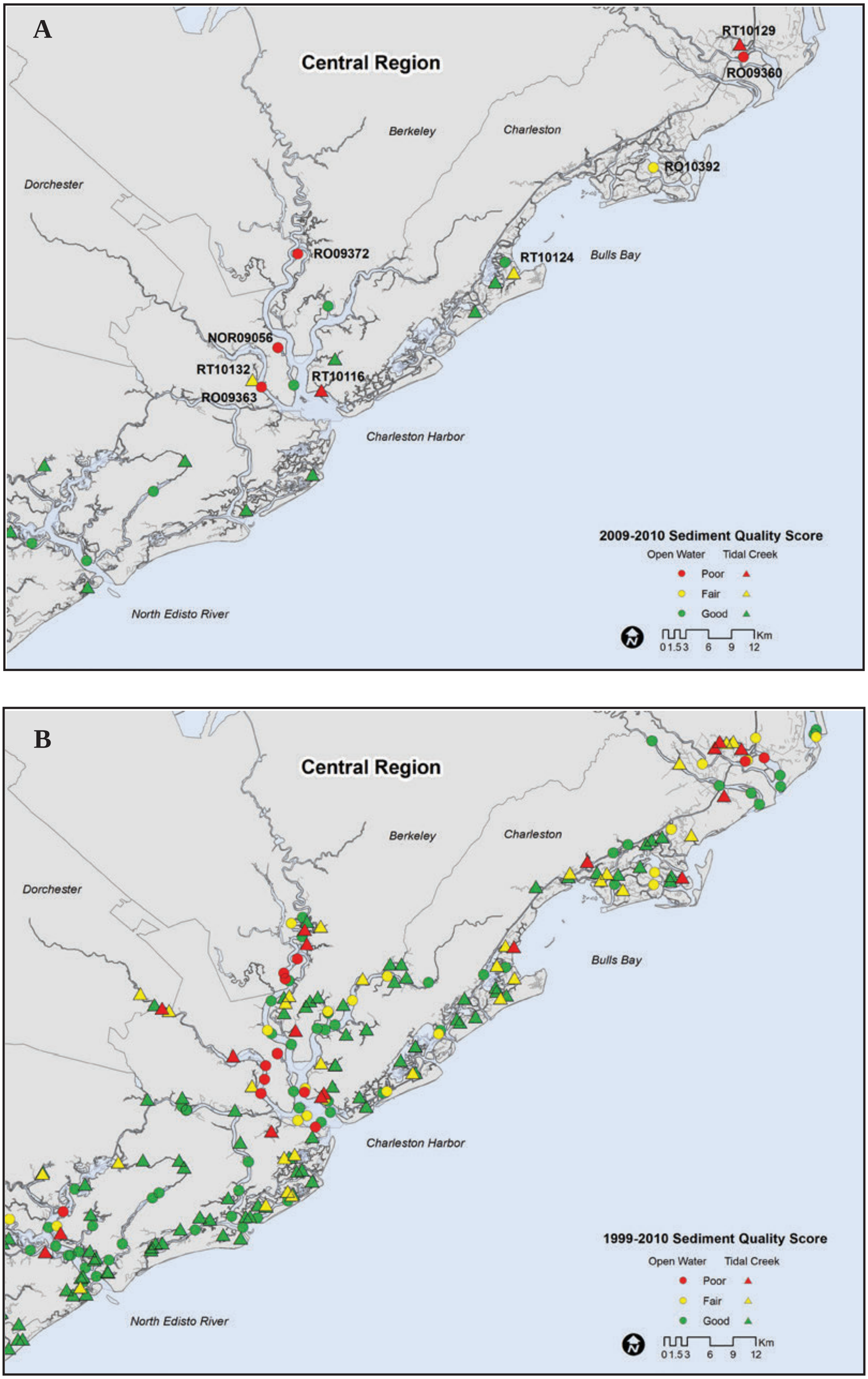
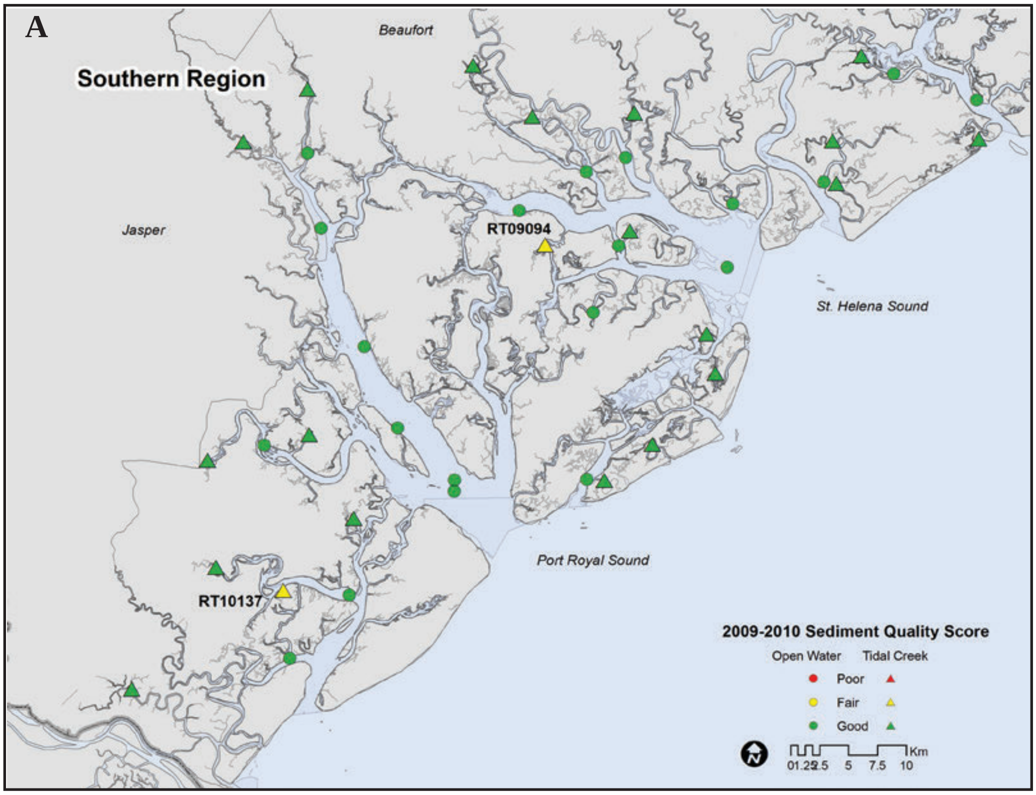


Figure 3.2.5. Distribution of stations with good, fair or poor scores for the Sediment Quality Index during the 2009-2010 (A) and 1999-2010 (B) periods for the central region of South Carolina.



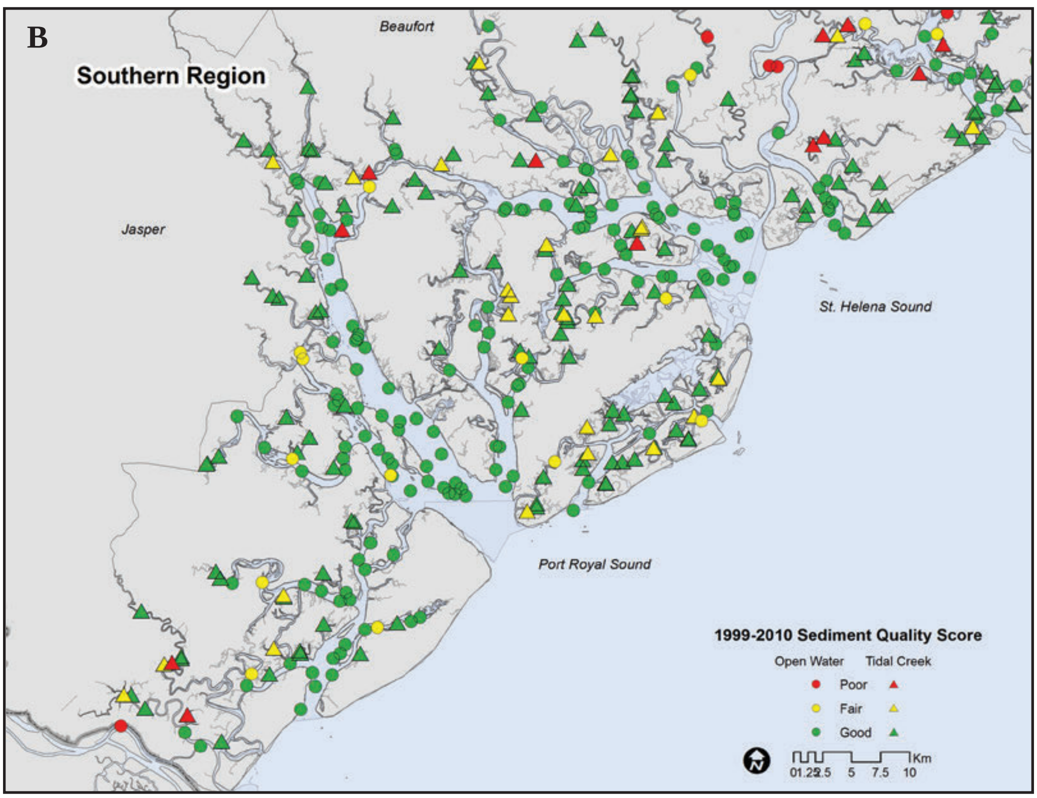


Figure 3.2.6. Distribution of stations with good, fair or poor scores for the Sediment Quality Index during the 2009-2010 (A) and 1999-2010 (B) periods for the southern region of South Carolina.

3.3. Biological Condition

Benthic Communities:

Benthic macrofauna serve as ecologically important components of the food web by consuming detritus, plankton, and smaller organisms living in the sediments and in turn serving as prey for finfish, shrimp, and crabs. Benthic macrofauna are also relatively sedentary, and many species are sensitive to changing environmental conditions. As a result, those organisms are important biological indicators of water and sediment quality and are useful in monitoring programs to assess overall coastal and estuarine health (Hyland et al., 1999; Van Dolah et al., 1999).

Using the Benthic Index of Biotic Integrity (B-IBI), 82% of South Carolina's estuarine habitat was in good condition with 15% in fair and 3% in poor condition in terms of benthic community quality during the 2009-2010 survey period (Figure 3.3.1). As in previous surveys, a greater percentage of open water habitat scored as good (83%) compared to tidal creek habitat (73%) (Appendix 2). The greater percentage of fair and poor habitat in the tidal creek habitats likely reflects the more stressful conditions of shallow tidal creek systems compared to tidal rivers and bays. The percentage of habitat scoring as good for the B-IBI is on average similar to most of the previous survey periods since SCECAP began in 1999 (Figure 3.3.2).

The 2009-2010 B-IBI average scores for open water and tidal creek habitats are 3.5 and 3.1, respectively, which are slightly lower than the 1999-2010 average B-IBI scores (open water – 3.7, tidal creek – 3.3). In fact the lowest B-IBI average score (2.67) for a given year since 1999 occurred in the tidal creek habitat in 2010 (Table 3.3.1).

Similar to the WQI and SQI, the B-IBI showed a pattern of greater amount of habitat in good condition during periods of lower rainfall; however, the pattern was not statistically significant. In previous reports, this pattern is discussed in relation to differences in salinity within the state's estuaries with the annual average B-IBI being positively related to annual average salinity (Bergquist et al., 2011); however, the pattern is not as strong with the addition of the 2009 and 2010 data. A primary component of the B-IBI is the number of species by station (Van Dolah et al., 1999). During periods of lower rainfall

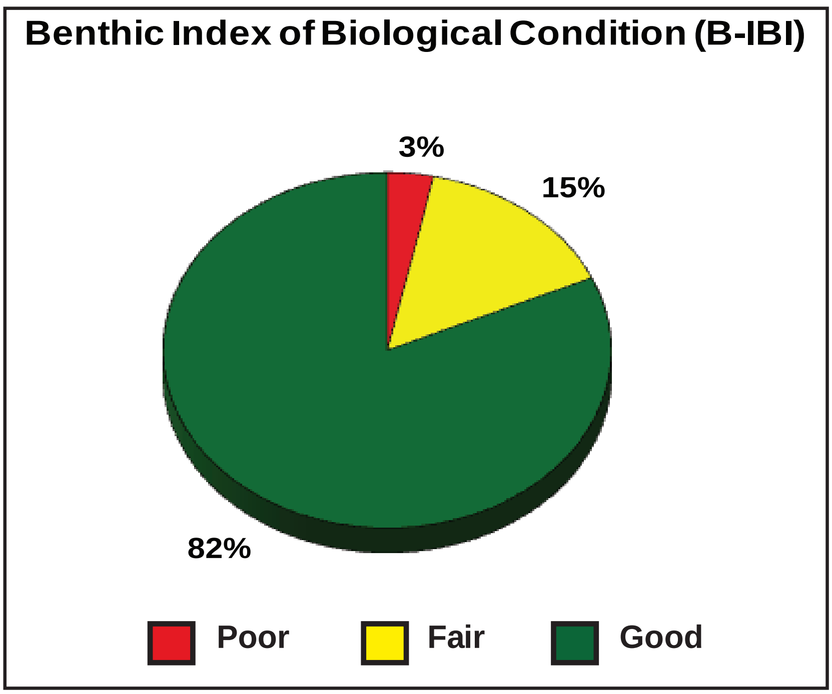


Figure 3.3.1. Percentage of the state's estuarine habitats that scored as good, fair, or poor for the B-IBI during 2009-2010.

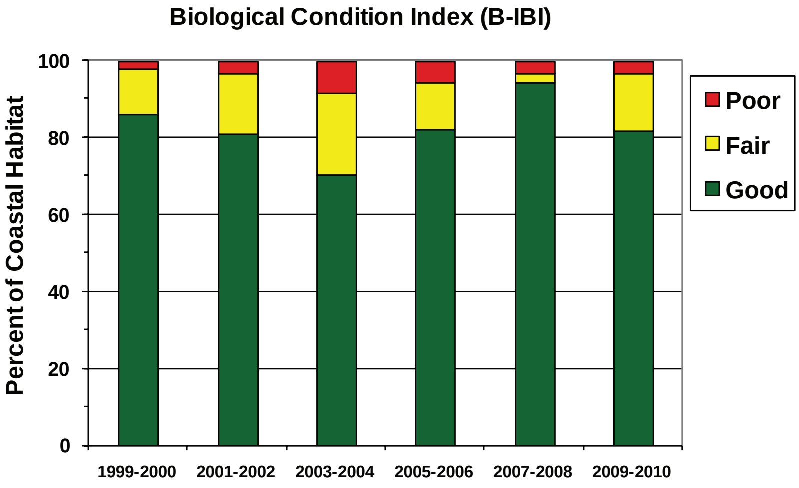


Figure 3.3.2. B-IBI by survey period for the state's estuarine habitats.

and higher estuarine salinity, a larger number of marine species can inhabit estuarine systems, thus increasing the number of species present and improving the B-IBI. Although this suggests that salinity represents an important confounding factor in the interpretation of the B-IBI, it is important to note that the B-IBI index thresholds are adjusted for different salinity conditions and the index is still capable of distinguishing habitats of differing stress. This is clearly apparent in the lower B-IBI score of creek habitats for any given salinity.

The B-IBI provides a convenient, broad index of benthic community condition, but because this index combines four measures into a single value, it does not provide detailed information on community composition. While most of the benthic community measures shown in Table 3.3.1 do not explicitly identify degraded conditions, they do allow the comparison of community characteristics among habitats and through time. Traditional community descriptors such as total faunal density, number of species (species richness), species evenness (J'), and species diversity (H') can be lower in more stressful environments. This is because fewer and fewer species within a community can tolerate increasingly stressful conditions, such as those caused by decreasing dissolved oxygen or increasing sediment contamination. Using all SCECAP data collected since 1999, open water habitats tended to have significantly higher values than tidal creeks for all of these measures (Table 3.3.1). This likely reflects a combination of factors including the naturally stressful conditions of shallower tidal creeks, the closer proximity of tidal creeks to upland development, and the greater influence of high diversity marine communities on open water habitats. Using published literature, species that are sensitive to pollution can be identified in order to examine potential patterns in estuarine contamination. As with the more traditional indices above, open water habitats supported significantly higher densities and percentages of sensitive fauna than tidal creek habitats (Table 3.3.1). Taxonomic groups, such as amphipods, mollusks and polychaetes, occupy a diverse range of habitats, but relative to each other, vary predictably with environmental conditions. For example, polychaetes tend to dominate the communities of shallow, muddy tidal creek habitats whereas amphipods and mollusks become increasingly more abundant in sandier oceanic environments (Little, 2000). A comparison between tidal creek and open water habitats support these expected patterns, with the densities and proportions of amphipods and mollusks being higher in open water habitats and the proportion of polychaetes being higher in tidal creek habitats (Table 3.3.1).

The distribution of stations with good, fair or poor B-IBI scores during the 2009-2010 period is shown in Figures 3.3.4a, 3.3.5a, 3.3.6a; Appendix 3. Only two stations scored as poor for B-IBI scores: one station was located in the Cooper River just inside Flag Creek in Charleston Harbor (RT09372), and the second station was located in a creek of the Chehaw River west of Big Island which drains into the Coosaw River within the ACE Basin (RT10131) (Figures 3.3.5a, 3.3.6a). Poor to fair B-IBI values have been associated with both of these areas during past surveys. Fair B-IBI scores were observed at eleven stations throughout the state. Historically, poor to fair B-IBI scores have been observed in Winyah Bay, other parts of Charleston Harbor, the North Edisto River and some of the more inland creeks that drain into St. Helena Sound and Port Royal Sound (Figure 3.3.6). However, care should be exercised when interpreting these scores in shallower tidal creeks as the B-IBI was largely derived from data collected from larger water bodies. As noted previously, environmental characteristics and their effects on benthic communities can be substantially different between the two habitat types.

Table 3.3.1. Summary of mean benthic biological measures observed in tidal creek and open water habitats during each year of the SCECAP survey. Blue highlight indicates the measure used to represent Biological Condition.

		Year											
Measure	**Habitat**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
B-IBI	Open	3.76	3.73	3.55	3.88	3.48	3.55	3.72	3.50	3.97	3.93	3.40	3.60
	Creek	3.24	3.68	3.36	3.37	3.03	3.25	3.00	3.50	3.37	3.87	3.50	2.67
Density (indiv/m^2)	Open	5354	6294	4095	7198	4236	4127	5282	4513	7230	8634	2702	3246
	Creek	2363	4659	4710	5001	3198	2863	2282	5060	3044	6402	2846	2133
Number of Species	Open	25.9	22.2	17.5	26.7	18.9	18.7	21.0	19.0	23.1	23.9	15.30	18.83
	Creek	14.8	19.8	17.5	20.7	14.4	16.0	12.0	22.2	14.5	23.4	15.73	10.63
Species Evenness (J')	Open	0.76	0.70	0.72	0.73	0.73	0.74	0.74	0.77	0.69	0.68	0.78	0.79
	Creek	0.72	0.69	0.71	0.70	0.73	0.72	0.75	0.67	0.74	0.72	0.72	0.67
Species Diversity (H')	Open	3.30	2.81	2.74	3.14	2.67	2.84	2.94	2.99	2.98	3.01	2.72	3.16
	Creek	2.60	2.85	2.78	2.78	2.35	2.64	2.41	2.75	2.67	3.04	2.72	2.05
Sensitive Taxa Density	Open	764	1986	615	1045	854	900	1572	959	1223	1330	396	382
	Creek	313	965	694	528	465	260	338	705	330	680	358	222
Percent Sensitive Taxa	Open	13.3	26.7	18.2	15.5	16.3	23.6	19.4	17.6	18.6	18.0	12.80	13.16
	Creek	9.8	16.2	10.7	6.5	10.3	8.4	13.3	13.6	13.9	13.1	13.64	7.96
Amphipod Density	Open	687	927	243	979	870	802	1391	283	745	384	463	287
	Creek	113	753	193	248	331	176	346	560	1247	1061	343	19
Mollusc Density	Open	259	327	303	516	302	193	141	627	436	409	188	123
	Creek	123	265	193	208	144	91	34	283	99	246	118	53
Other Taxa Density	Open	1555	1280	808	1059	766	605	925	929	1993	2233	716	599
	Creek	339	824	924	684	880	556	423	547	485	868	750	355
Polychaete Density	Open	2855	3761	2740	4644	2298	2182	2772	2481	4057	5608	1325	2228
	Creek	1788	2818	3401	3861	1844	2129	1479	3421	1213	4228	1635	1693
Percent Amphipods	Open	10.9	18.6	12.7	13.2	17.5	17.5	16.4	12.7	13.6	9.5	12.12	15.66
	Creek	6.1	11.8	4.5	5.3	7.8	4.7	12.9	10.4	13.5	14.1	8.57	1.62
Percent Molluscs	Open	5.9	7.9	10.0	9.6	7.8	8.5	2.8	10.5	6.3	6.3	7.89	5.23
	Creek	3.5	6.0	5.7	6.2	5.6	4.7	1.8	5.0	4.4	3.5	4.91	1.99
Percent Other Taxa	Open	26.7	19.2	16.9	20.0	22.4	21.8	23.9	25.4	27.6	24.4	28.82	17.47
	Creek	21.6	24.4	20.0	17.6	33.2	19.6	25.8	14.4	23.3	17.6	27.19	18.02
Percent Polychaetes	Open	56.4	54.3	60.3	57.2	52.3	50.3	56.4	50.3	52.5	59.6	50.14	61.37
	Creek	68.8	57.8	69.7	70.9	53.4	71.0	59.4	68.5	58.7	64.7	59.33	74.09

Finfish and Large Invertebrate Communities:

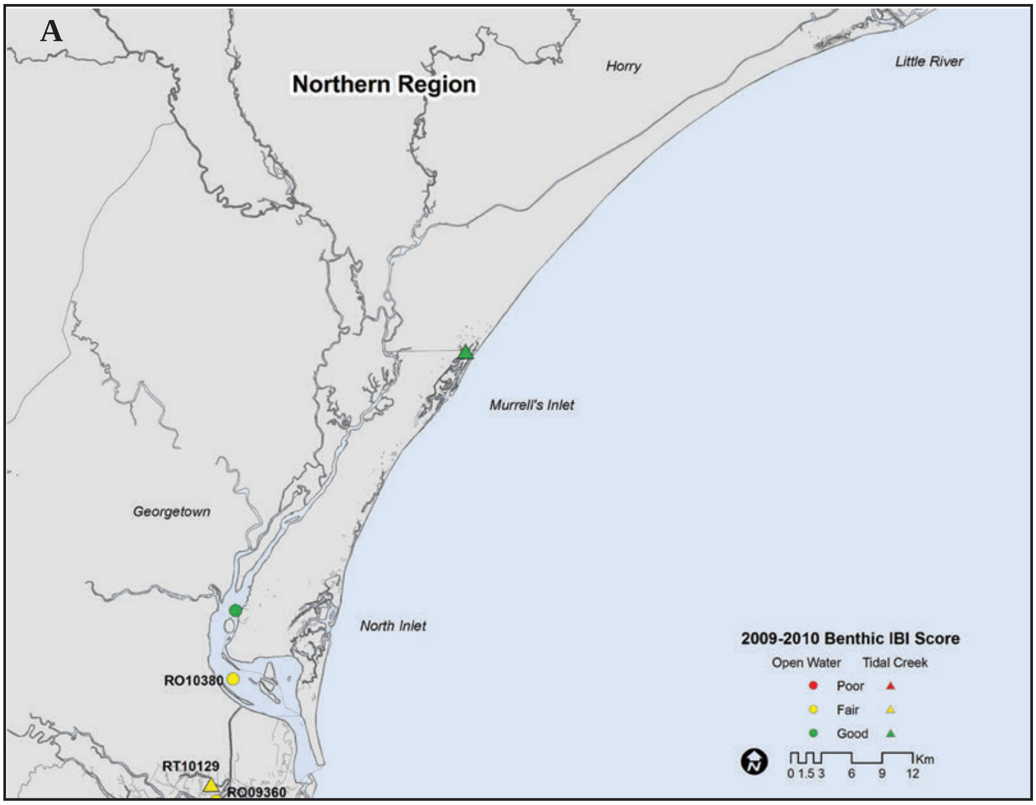
South Carolina's estuaries provide food, habitat, and nursery grounds for diverse communities of fish and larger invertebrates such as shrimp and blue crab (Joseph, 1973; Mann, 1982; Nelson et al., 1991). These communities include many important species that contribute significantly to the state's economy and the well-being of its citizens. Estuaries present naturally stressful conditions that limit species' abilities to use this habitat. Add to that human impacts, such as commercial and recreational fishing, coastal urbanization, and habitat destruction, and the estuarine environment can change substantially, leading to losses of important invertebrate and fish species. Densities of vertebrates (fish, rays, etc.), decapods (crabs, shrimp, etc.) and all fauna combined were generally higher in tidal creek habitats compared to open water habitats (Table 3.3.2). This likely reflects the importance of shallower creek habitats as refuge and nursery habitat for many of these species. In general, all of the finfish and large invertebrate community (except croaker density and spadefish density, both in tidal creeks) has been decreasing since 1999. This trend could become a significant concern if it continues over a longer period.

SCECAP provides a fishery-independent assessment of several of South Carolina's commercially and recreationally-important fish and crustacean species. Of these, the most common species collected by SCECAP include the fish: spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), weakfish (*Cynoscion regalis*), silver perch (*Bairdiella chrysoura*), and Atlantic spadefish (*Chaetodipterus faber*), and the crustaceans: blue crab (*Callinectes sapidus*), white shrimp (*Litopenaeus setiferus*), and brown shrimp (*Farfantepenaeus aztecus*). All of these species, with the exception of weakfish and Atlantic croaker, were generally more abundant in tidal creek habitats (Table 3.3.2). In a recent detailed analysis of spot, Atlantic croaker and weakfish catches, Crowe et al. (2011) found evidence that Atlantic croaker is remaining constant through time, while both weakfish and spot are decreasing, the former due to decreasing abundances and the latter due to decreasing occurrence.

3.4. Incidence of Litter

As the coastline of South Carolina develops and more people access our shorelines and waterways, the incidence of litter (plastic bags and bottles, abandoned crab traps, etc.) is likely to increase. The primary sources of litter include storm drains, roadways and recreational and commercial activities on or near our waterways. Beyond the visual impact, litter contributes to the mortality of wildlife through entanglement,

Litter and the abandonment of vessels create unsightly vistas of our coastal shoreline and can be sources of pollution to adjacent waters and sediments.



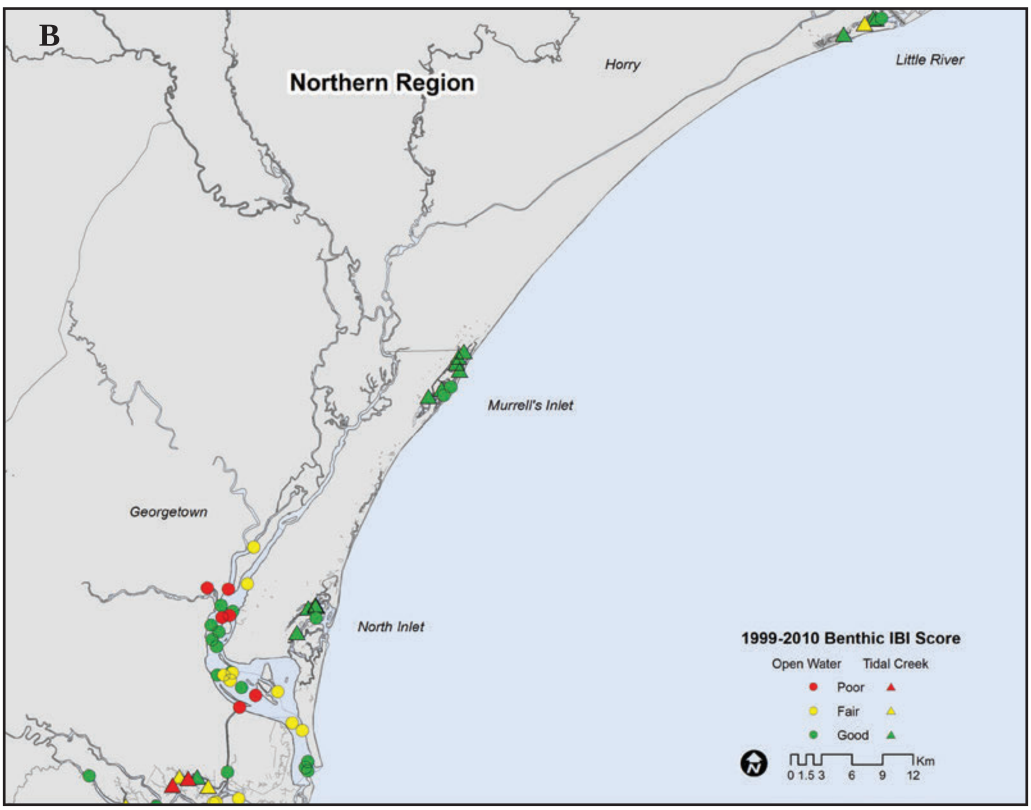
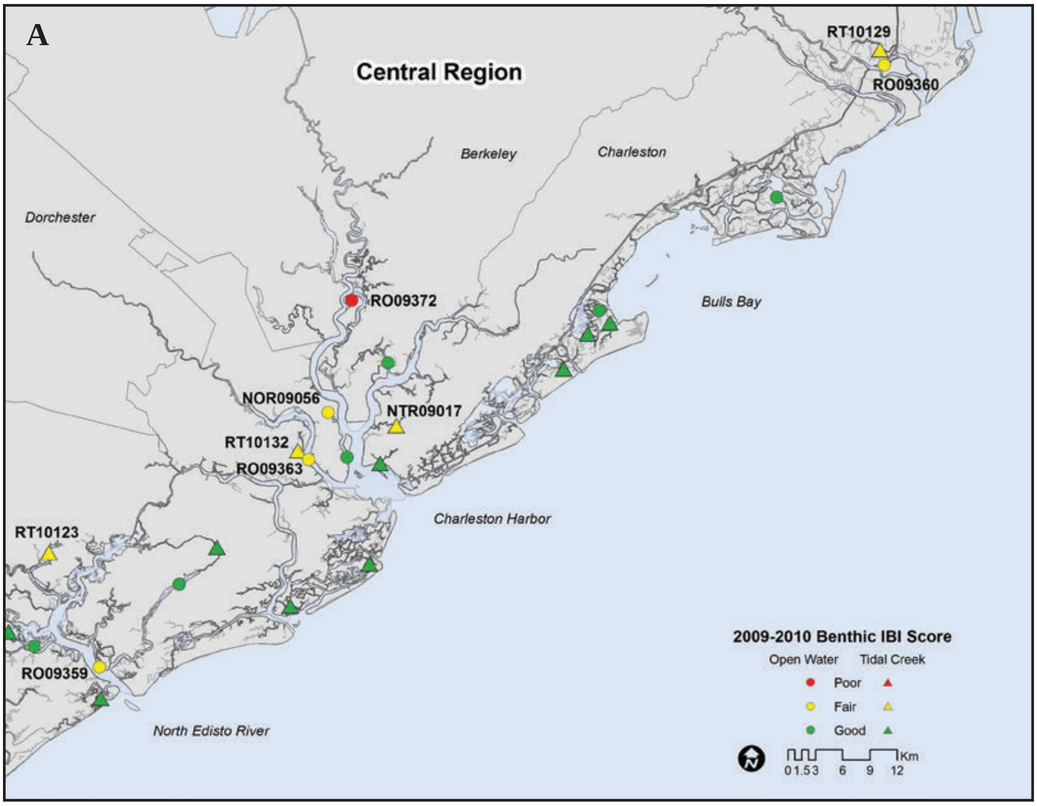


Figure 3.3.4. Distribution of stations with good, fair or poor scores for the B-IBI during the 2009-2010 (A) and 1999-2010 (B) periods for the northern region of South Carolina.



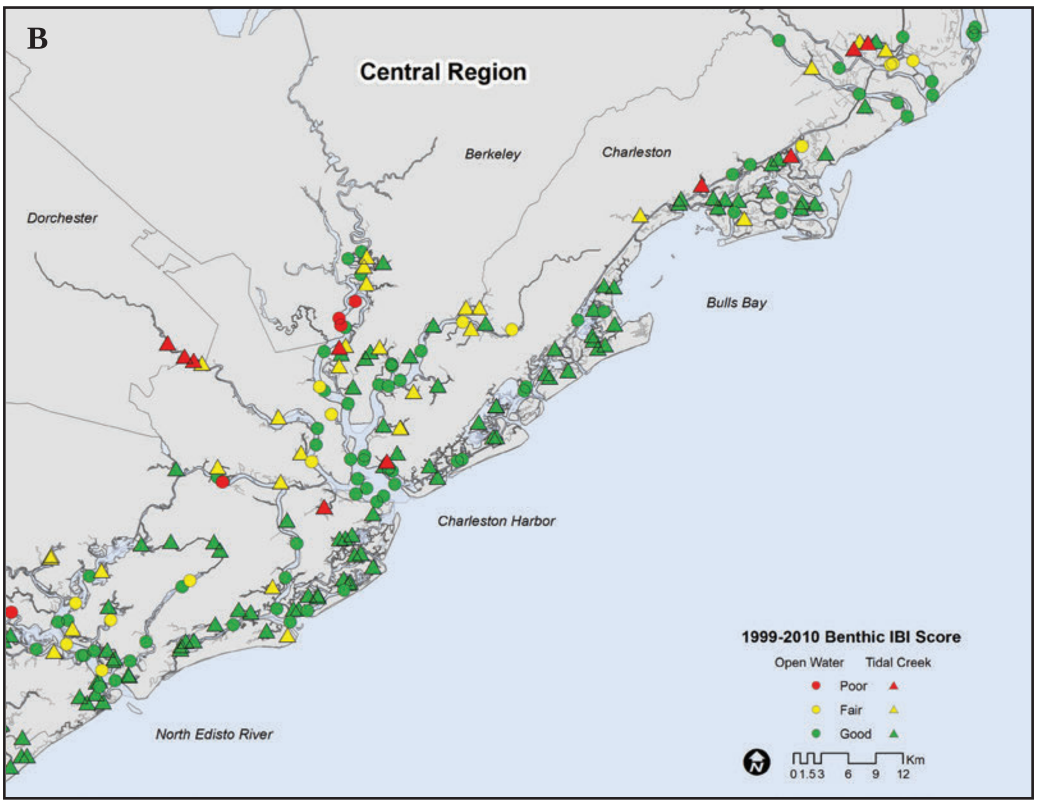
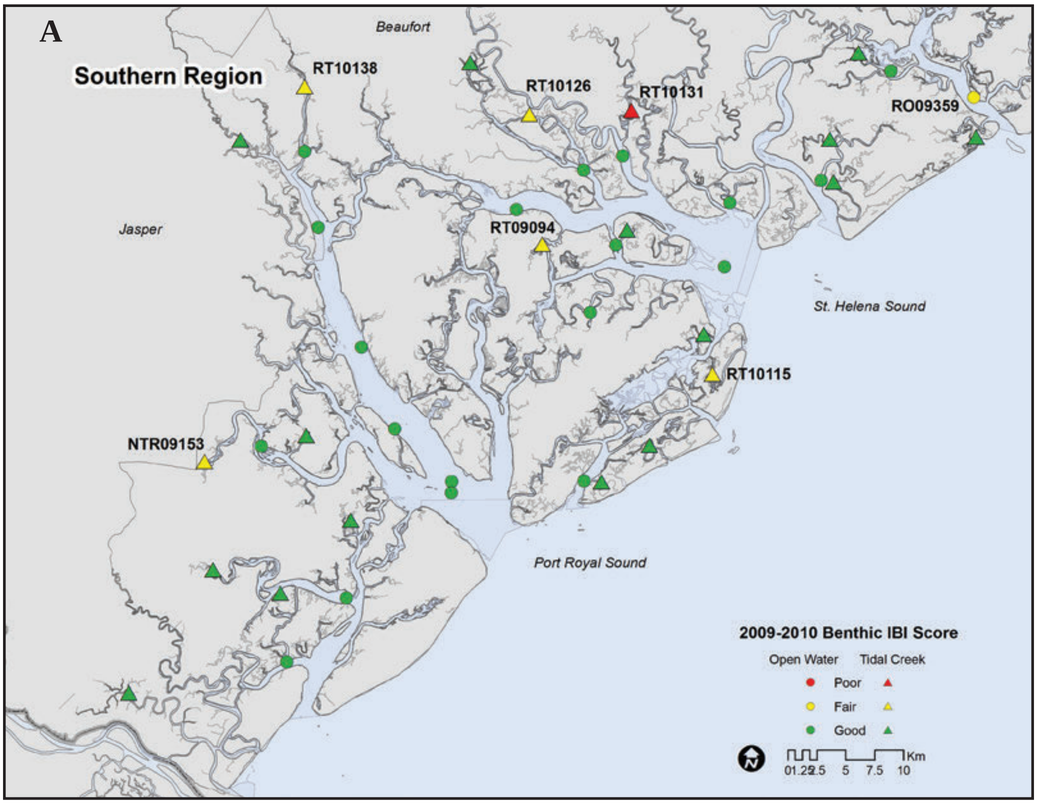


Figure 3.3.5. Distribution of stations with good, fair or poor scores for the B-IBI during the 2009-2010 (A) and 1999-2010 (B) periods for the central region of South Carolina.



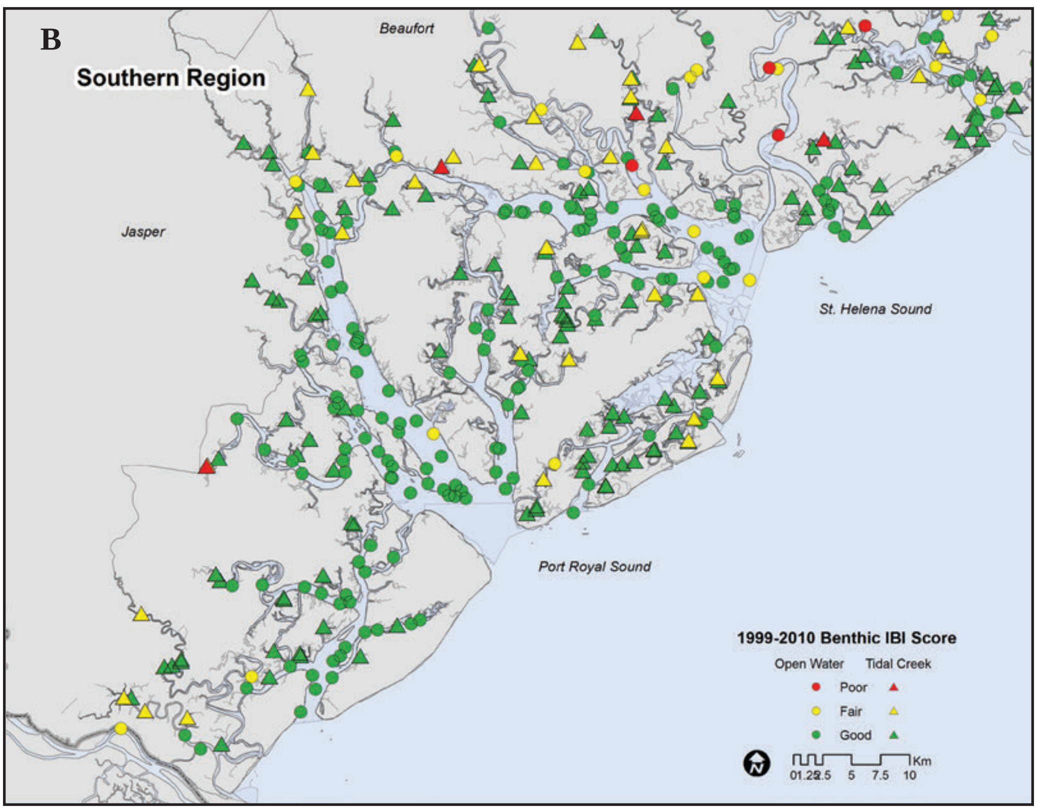


Figure 3.3.6. Distribution of stations with good, fair or poor scores for the B-IBI during the 2009-2010 (A) and 1999-2010 (B) periods for the southern region of South Carolina.

Table 3.3.2. Summary of mean finfish and large invertebrate biological measures observed in tidal creek and open water habitats during each year of the SCECAP survey.

		Year											
Measure	**Habitat**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Overall Density	Open	317	324	376	556	325	450	380	442	280	108	91	246
	Creek	800	852	698	1098	759	1319	736	1611	296	295	331	817
No. Species	Open	8.00	7.76	7.97	9.13	7.45	8.20	8.12	7.96	8.33	6.00	4.73	8.00
	Creek	8.54	9.86	8.16	9.31	8.40	9.30	9.24	8.00	7.07	6.57	6.71	9.36
Vertebrate Density	Open	195.4	197.7	195.7	297.1	178.3	216.9	195.7	216.9	154.1	85.7	36.7	99.0
	Creek	302.5	372.7	319.1	263.6	299.1	330.8	308.4	171.2	99.0	195.7	98.3	168.1
No. Vertebrate Species	Open	5.5	5.2	5.7	6.5	5.6	5.9	5.9	6.2	6.1	4.5	3.7	5.1
	Creek	5.8	6.8	5.7	6.7	6.0	6.4	6.4	6.0	5.2	5.0	4.8	6.2
Decapod Density	Open	86.3	96.4	165.7	247.6	136.8	211.2	165.5	212.2	111.2	14.3	52.7	138.2
	Creek	458.1	424.2	345.5	761.1	428.6	943.6	383.8	1415.9	181.9	74.4	207.4	632.9
No. Decapod Species	Open	2.1	2.5	2.0	2.4	2.1	2.0	2.0	1.9	1.9	1.3	1.4	2.3
	Creek	2.0	2.4	2.0	2.1	2.0	2.4	2.6	1.8	1.8	2.1	1.6	2.6
Spot Density	Open	6.36	18.24	64.77	26.79	23.19	49.16	56.81	29.13	11.79	19.81	0.97	10.63
	Creek	69.78	130.98	111.54	37.92	71.02	95.14	146.54	23.57	13.04	43.96	28.99	38.16
Croaker Density	Open	3.00	48.31	35.76	111.88	71.00	24.64	26.81	26.53	50.96	4.35	4.59	11.11
	Creek	8.32	7.52	15.65	17.39	12.45	6.28	5.53	1.45	14.01	0.97	10.63	25.12
Weakfish Density	Open	11.1	23.7	22.4	41.5	2.9	52.3	10.7	13.8	10.9	9.9	1.9	8.2
	Creek	13.7	6.0	3.8	11.8	3.2	3.5	7.9	2.3	7.8	3.9	3.9	1.4
White Perch Density	Open	42.2	8.6	5.8	5.8	4.8	2.1	6.4	8.8	6.4	0.7	0.7	5.6
	Creek	95.5	93.6	31.5	95.6	31.1	35.3	28.7	59.7	18.3	11.6	9.7	14.5
Spadefish Density	Open	4.62	3.99	0.72	5.80	0.97	4.25	6.38	6.81	1.69	0.72	3.14	4.11
	Creek	3.76	2.85	2.90	7.73	0.70	12.81	6.10	11.30	1.93	3.86	1.93	9.18
Blue Crab Density	Open	1.5	8.3	1.1	1.1	2.5	3.4	3.5	5.7	0.5	0.0	0.5	1.4
	Creek	4.0	22.4	5.2	5.3	10.5	18.4	20.6	8.5	9.8	3.4	0.5	13.5
Brown Shrimp Density	Open	8.0	41.8	104.3	69.0	51.3	34.1	45.7	34.3	62.7	8.5	9.9	46.9
	Creek	122.4	68.6	97.1	130.9	66.8	128.3	150.1	40.7	26.6	37.2	13.0	96.6
White Shrimp Density	Open	74.6	41.8	54.0	165.7	78.1	172.7	110.9	170.2	42.7	5.6	42.0	88.2
	Creek	326.1	323.5	238.1	610.3	347.5	792.3	208.3	1364.1	142.6	25.1	192.9	507.7

primarily fishing line and fishing nets, and through ingestion of plastic bags and other small debris particles. Additionally, invasive species can be spread through the movement of litter from one area to another.

During the 2009-2010 survey period, litter was visible in 19% of our state's estuarine habitat (Figure 3.4.1). When each habitat type is considered separately, litter was visible in 17% of the state's tidal creek and 20% of the open water habitats. This is the second survey period where more litter was identified in open water than in tidal creek habitats. The level of litter has decreased since the last survey period (2007-2008), but is still high in comparison to prior years.

3.5. Overall Habitat Quality

Using the Habitat Quality Index (HQI) for the 2009-2010 assessment period, 84% of South Carolina's coastal estuarine habitat (tidal creek and open water habitats combined) was in good condition (Figure 3.5.1). Only 3% of the coastal estuarine habitat was considered to be in poor condition and 13% in fair condition. When the two habitats were considered separately, a greater percentage of tidal creek habitat was in fair to poor condition (27% fair, 0% poor) as compared to open water habitats (10% fair, 3% poor) in the 2009-2010 survey (Appendix 2). This difference between tidal creek and open water habitats is consistent with previous SCECAP surveys; however, this is the first time period for which no percentage of poor conditions was observed in the tidal creek habitats. The amount of habitat scoring as good for the HQI during 2009-2010 (84%) was similar to the previous study periods (77-86%) with the exception of the 2007-2008 period when 90% of the habitat was scored as good (Figure 3.5.2). The amount of habitat scoring as poor and fair were similar to previous survey periods (2-8% and 12-16%, respectively). The 2009-2010 coastal habitat scoring as good for the HQI is on the higher range and is consistent with the scoring as good for the WQI and SQI, and is likely tied to coastal rainfall patterns.

During the 2009-2010 study period, SCECAP stations with fair or poor habitat quality were scattered across the state (Figures 3.5.3a, 3.5.4a, 3.5.5a Appendix 3). The only site with a poor HQI score was located in the Cooper River just inside Flag Creek within the Charleston Harbor system

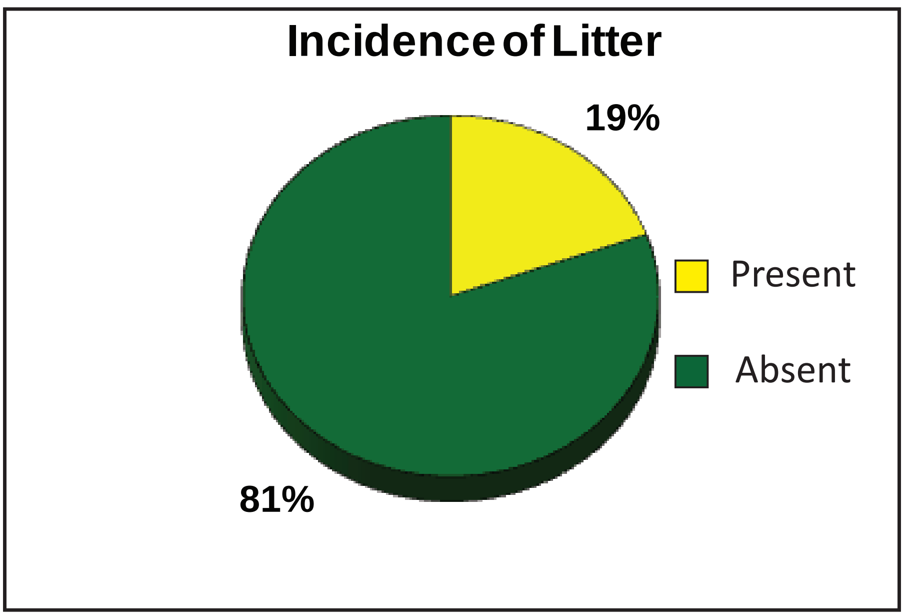


Figure 3.4.1. Percentage of the state's estuarine habitat with litter present during the 2009-2010 survey period.

(RO09372). This station also scored poor for both the SQI and B-IBI but good for the WQI. Twelve stations with fair habitat quality were observed during the 2009-2010 period with most of the stations sampled in 2010. Three of the stations with fair habitat quality were located in the Charleston Harbor system: Ashley River just below the Citadel Military College (RO09363), Oldtown Creek at Charles Towne Landing (RT10132), and Charleston Harbor in the mouth of Shem Creek (RT10116). Two stations with poor scores were also located in the central region: Bulls Bay in Bull Creek (RT10124) and North Edisto River in Toogoodoo Creek (RT10123).

In the northern region, three stations with fair habitat quality were located in Winyah Bay just north of the Middle Ground (RO10380), North Santee River in Minim Creek (RT10129), and North Santee River in the ICWW near Crow Island (RO09360). In the southern region, four stations were found to have a fair habitat score. Three stations were located in the St. Helena Sound upper system including Lucy Point Creek west of Coosaw Island (RT09094), Schooner Channel east of Wimbee Creek (RT10126), and Chehaw River west of Big Island (RT10131). One station with a fair habitat score was located in Pocotaligo River west of Oak Grove Plantation (RT10138). Stations in Winyah Bay, the Santee delta region, the North Edisto near Dawhoo Creek and the rivers draining into Charleston Harbor historically show a persistent pattern of degraded habitat quality (Figure 3.5.4). Winyah Bay and Charleston Harbor both have a history of industrial activity and/or high-density urban development that likely contributed to the degraded conditions in these areas. The causes of degraded habitat quality in

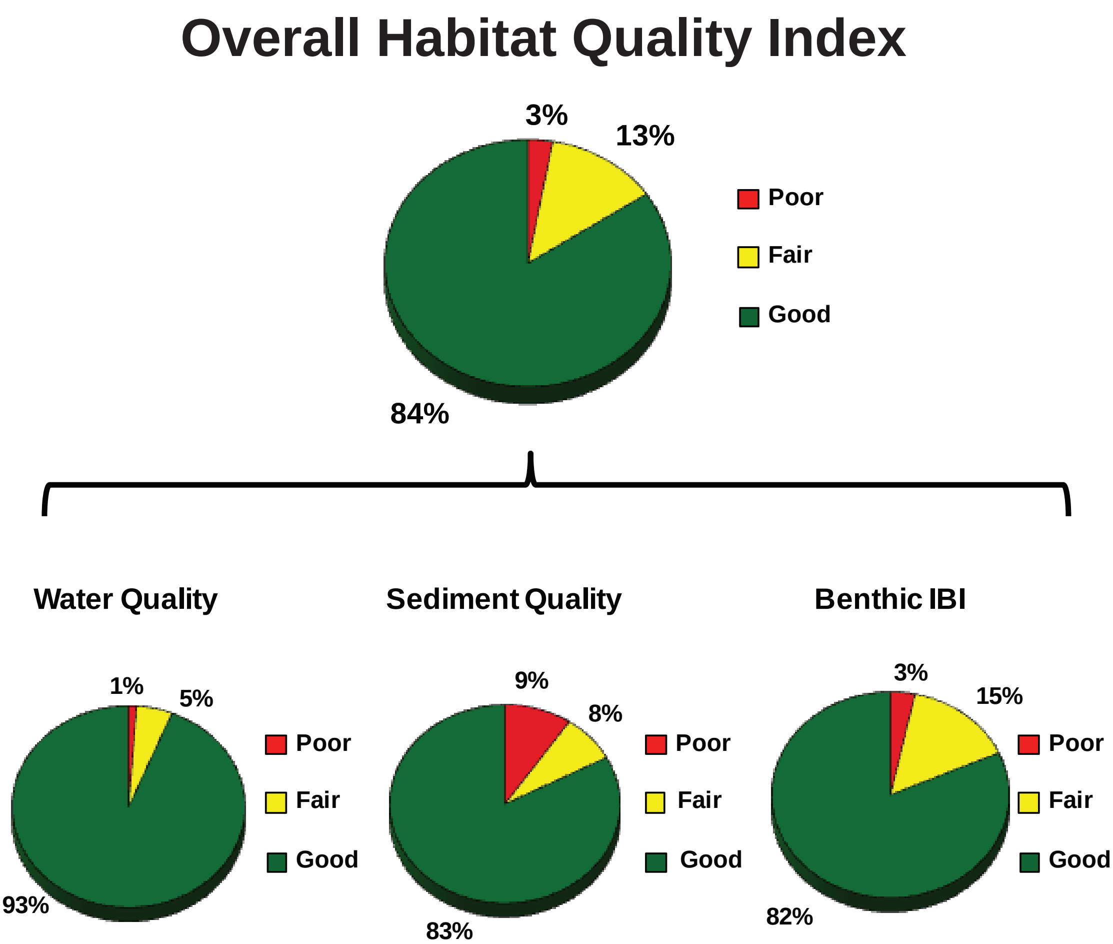


Figure 3.5.1. Percentage of the state's estuarine habitats that scored as good, fair, or poor for the integrated Habitat Quality Index during 2009-2010.

the areas draining into St. Helena Sound, home to the Ashepoo-Combahee-Edisto (ACE) Basin National Estuarine Research Reserve (NERR), are not clear but are currently under study by the SCDNR.

In addition, four non-random stations were sampled in 2009 at areas of concern from previous survey periods with the goal of determining whether there is evidence of changes in habitat condition in these locations. Three of these stations were located in areas where rapid development has occurred since the original sampling event (Hobcaw Creek in Mount Pleasant - NTR09017, May River near Bluffton - NTR09181, and Okatie River near the headwaters - NTR09153), and one station was in a system that was severely degraded originally but has since undergone remedial activities (Shipyard Creek - NOR09056) (Appendix 3). The Okatie River and May River

Revitalized waterfront with SC Aquarium and tour boat facilities. This area was badly contaminated prior to cleanup and reused for lower impact industries.

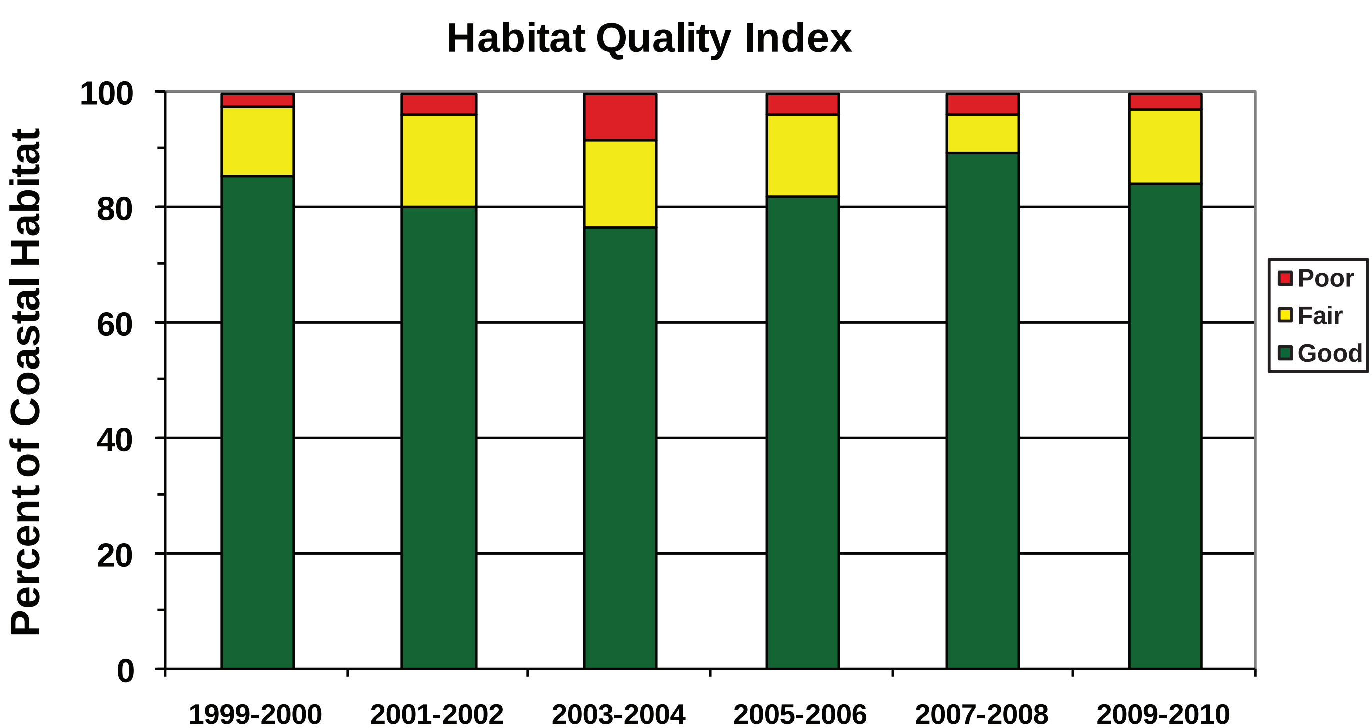
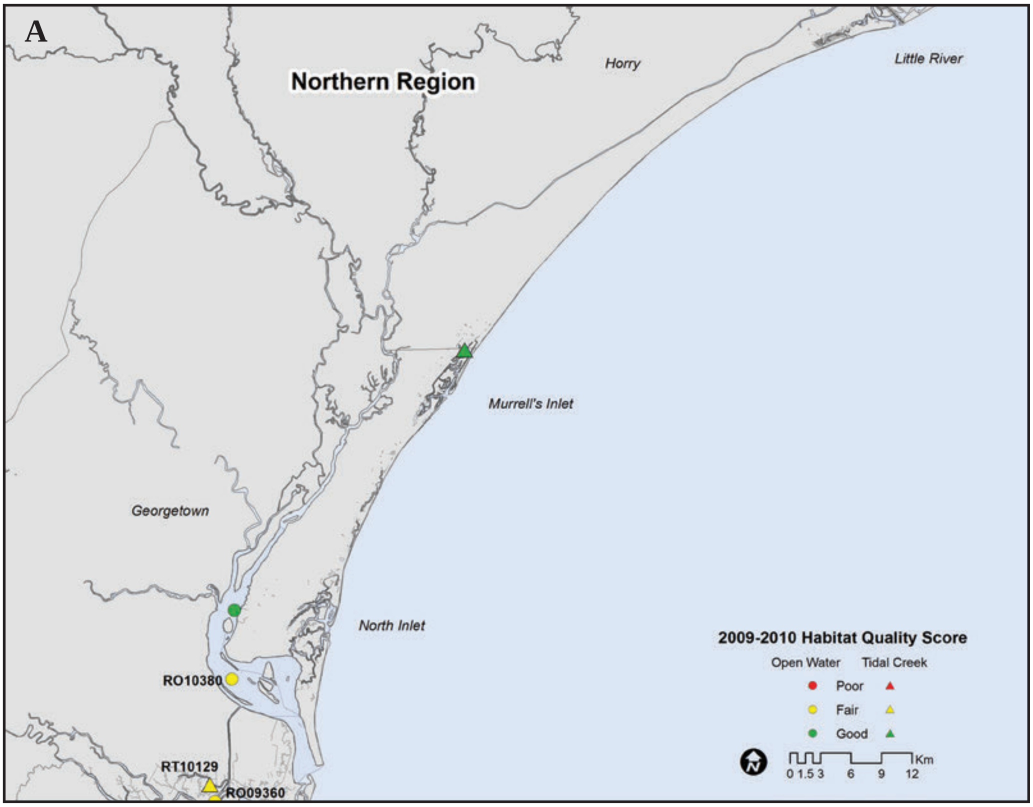


Figure 3.5.2. Habitat Quality Index scores by survey period for all estuarine habitat combined.



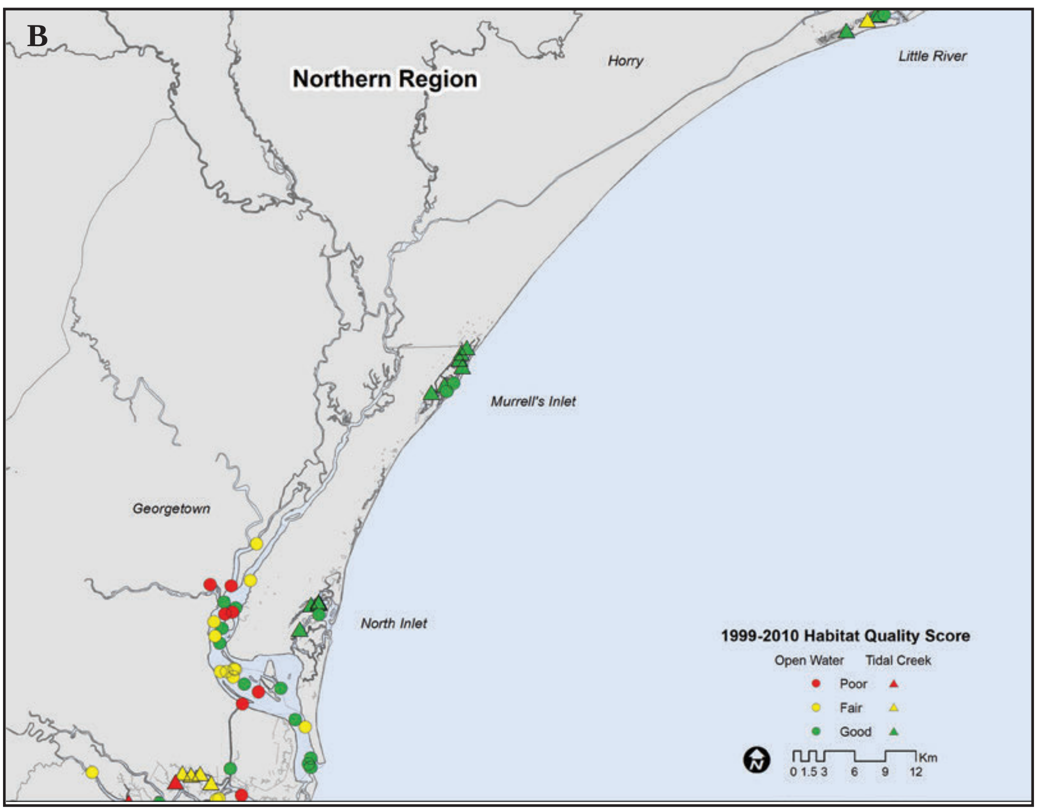


Figure 3.5.3. Distribution of stations with good, fair or poor scores for the Habitat Quality Index score during the 2009-2010 (A) and 1999-2010 (B) periods for the northern region of South Carolina.

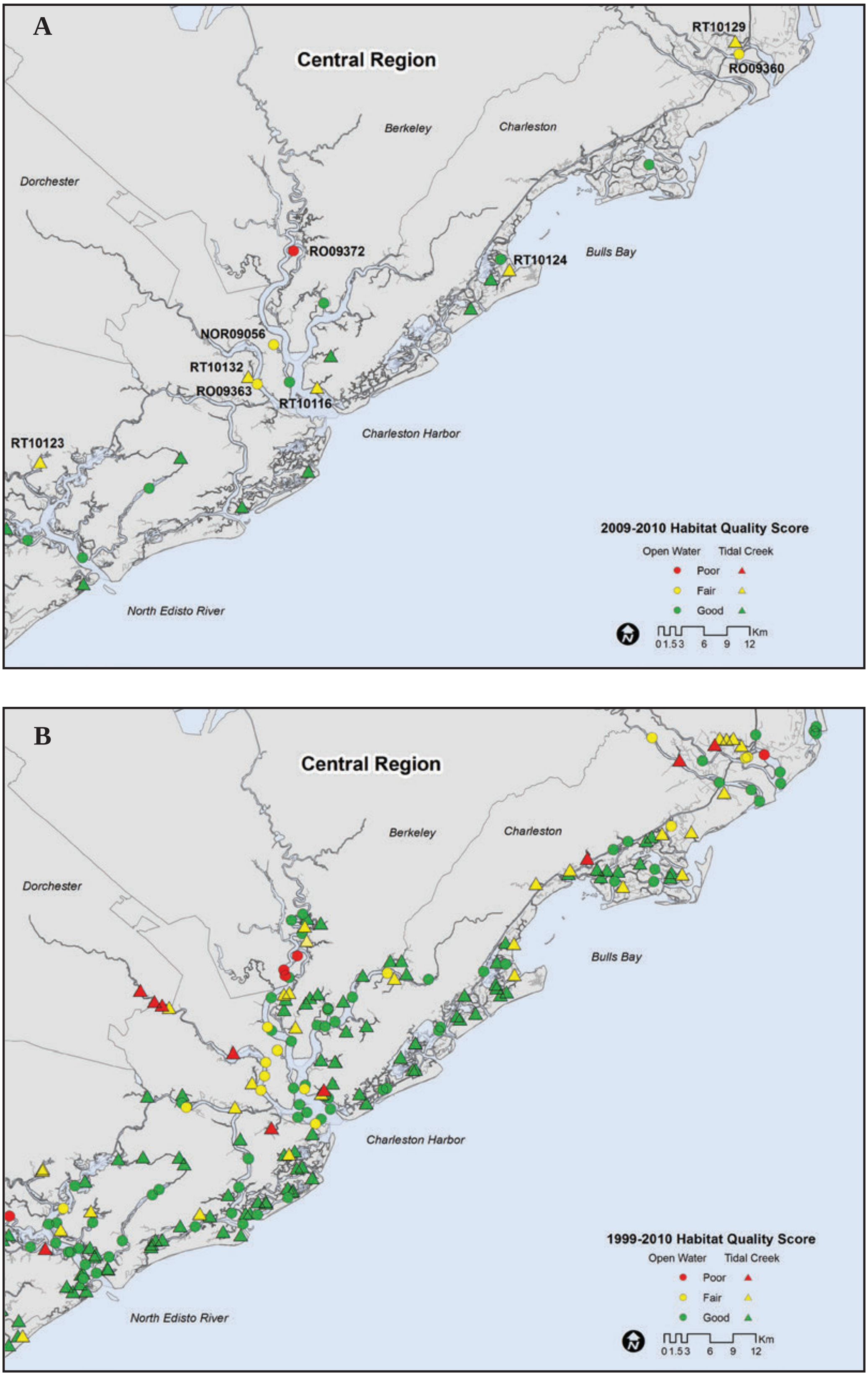


Figure 3.5.4. Distribution of stations with good, fair or poor scores for the Habitat Quality Index score during the 2009-2010 (A) and 1999-2010 (B) periods for the central region of South Carolina.

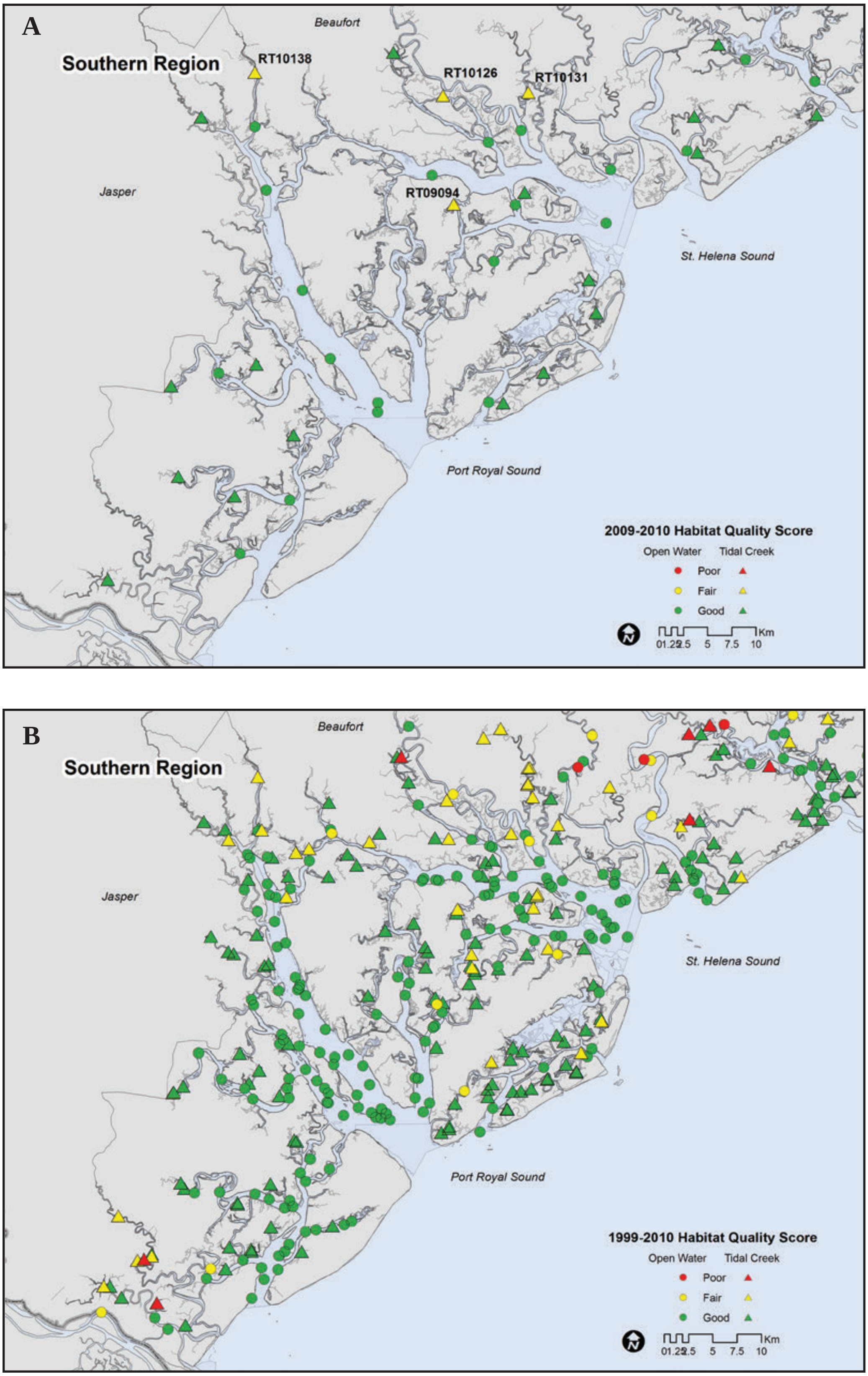


Figure 3.5.5. Distribution of stations with good, fair or poor scores for the Habitat Quality Index score during the 2009-2010 (A) and 1999-2010 (B) periods for the southern region of South Carolina.

stations were originally sampled during periods of high rainfall in comparison to the 2009 sampling which was during a period of low rainfall. As expected due to the rainfall amounts differences, the WQI and/or B-IBI increased from 2002/2003 to 2009. The Hobcaw Creek site was sampled during low rainfall periods for both events (1999 and 2009). This site showed an increase in the WQI and Habitat Quality over time. The Okatie River and Hobcaw sites showed a change from fair to good habitat quality between the time periods. The May River habitat quality was good for both time periods. The Shipyard Creek site remained the same with a fair habitat quality score between the two sampling periods (2000 and 2009). Therefore despite the cleanup efforts, the site continues to show degraded sediment quality.

3.6. Program Uses and Activities

SCECAP continues to be an effective collaboration between the SCDNR, SCDHEC, USEPA and NOAA to assess the condition of South Carolina's coastal environment. The results of these assessments have been used extensively in research, outreach, and planning by staff from these and other institutions and organizations. During the past two years, SCECAP data have been used to examine the distribution of sediment contaminants and general composition by the U.S. Army Corps of Engineers, especially with regard to Charleston Harbor, which is slated for deepening. SCDNR staff also mined the database for updated fishery independent information regarding the status of various finfish and crustacean stocks as part of the Division's annual assessment to create "State of the Resource" reports. The SCECAP benthic data-base also was mined for a significant national effort being led by the USEPA to develop a national benthic index. This database provided one of the few detailed empirical databases with species abundance data tied directly to sediment contaminant data, which was critically needed to evaluate pollution sensitivity of various species. Beaufort County requested water and sediment quality data for their use in managing and evaluating the condition of water bodies in that county. The National Park Service requested all information available from SCECAP in the vicinity of the national parks located in South Carolina. Finally, the SCECAP database provides one of the few sources of data on the distribution and relative abundance of key recreational species (e.g. spot, Atlantic croaker, weakfish) using unbiased sampling at a broad array of sites representing tidal creek and open water habitats. These data compliment information obtained from other SCDNR programs (e.g. inshore recreational finfish program), by sampling in areas those programs do not target, and by collecting a wealth of environmental data that can be used to relate stock condition to the health of estuarine systems.

During the 2009-2010 survey period, primary funding for this program was obtained from the USFWS Federal Aid in SportFish Restoration Act, and the USEPA National Coastal Assessment program. The latter funding was obtained through SCDHEC for the 2010 assessment. The program maintains sampling at a minimum of 30 sites each year to provide for a total of 60 sites (30 tidal creek, 30 open water) for each two year assessment period. This is considered to be the minimal effort required to make statistically defensible assessments of condition for the coastal waters of our state. Continuing this program on a long-term basis will provide valuable information on trends in estuarine condition that are likely to be affected by continued coastal development. Since South Carolina has experienced drought conditions in many of the last several years, coastal estuarine habitat quality has not experienced any significant decline since the inception of the program, although patterns related to runoff from upland areas have been observed. When the state's coastal zone returns to more normal rainfall conditions, it is likely that this valuable database will be instrumental in documenting and understanding the causes for any adverse changes that might occur in our coastal zone.

ACKNOWLEDGEMENTS

The credit for the immense amount of work involved in planning a project of this size, collecting, processing, analyzing the data, and finally writing this report goes to many people. Some have been involved since its inception in 1999 while others may have only been involved for a summer. Either way, the project cannot be completed without the dedicated efforts of these individuals. We would like to thank Dr. Derk Bergquist, who led the SCECAP efforts during the 2007-2010 seasons. Tony Olsen and staff at the USEPA NHEERL, Corvallis, OR assisted in developing the sampling design and CDF routines used during the analysis. The bulk of the field work falls on two groups, the staff of the SCDNR's Environmental Research Section and SCDHEC's Water Quality Monitoring and Modeling section. In addition to the authors, SCDNR field teams included Dany Burgess, Steve Burns, Joe Cowan, Stacie Crowe, Jordan Felber, Leona Forbes, John Heinsohn, Jared Hulteen, Brooke James, Nicole Kozlowski, and Amanda Powers and SCDHEC field staff included David Graves and Bryan Rabon. Once the diverse array of samples arrived back at the lab at the end of a field day, they were distributed to cooperating groups that included the ERS (many named above) that processed benthic community and sediment samples; the NOAA CCEHBR lab which processed sediment chemistry and toxicology assays (Brian Shaddrix, Lynn Thorsell, Brian Thompson, and Katy Chung); the SCDNR Algal Ecology Lab (Dianne Greenfield, Krista DeMattio, Jared Ragland, Sarah Williams, Chuck Keppler, and Lara Brock) that processed the algal samples and Justin Lewandowski, in the SCDHEC Aquatic Biology Section processed the chlorophyll-a samples. Staff at the SCDHEC Bureau of Environmental Services, Analytical and Radiological Environmental Services Division that processed the nutrient and fecal samples included Roger Brewer (Central Lab), Sharon Gilbert (Region 7 ECQ Trident Lab), Penny Cornett (Region 8 EQC Low Country Lab), and Leigh Plummer (Region 8 EQC Pee Dee Lab).

Funding for many long term monitoring projects may come from a variety of sources, and this project is no exception. Funding for the 2009-2010 survey period was provided by SCDNR, SCDHEC, the USEPA's NCA Program and a USFWS Recreational Finfish Restoration grant.

Finally, we wish to thank several individuals who provided technical peer-review of this document. Jeffrey Hyland and Marie DeLorenzo provided valuable comments that improved the quality of this report.

LITERATURE CITED

Bergquist, D.C., R.F. Van Dolah, G.H.M. Riekerk, M.V. Levisen, S.E. Crowe, L. Brock, D.I. Greenfield, D.E. Chestnut, W. McDermott, M.H. Fulton, E. Wirth, and J. Harvey. 2009. The Condition of South Carolina's Estuarine and Coastal Habitats During 2005-2006: Technical Report. Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 103. 69 pp.

Bergquist, D.C., R.F. Van Dolah, G.H.M. Riekerk, M.V. Levisen, S.E. Crowe, D.E. Chestnut, W. McDermott, M.H. Fulton, and E. Wirth. 2011. The Condition of South Carolina's Estuarine and Coastal Habitats During 2007-2008: Technical Report. Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 106. 64 pp.

Crowe, S.E., D.C. Bergquist, G.H.M. Riekerk, R.F. Van Dolah. 2011. Fishery-Independent Monitoring of Juvenile Nursery Habitat of Key Recreational Fishery Species. Final Report. Prepared for U.S. Department of the Interior, U.S. Fish and Wildlife Service.

Carlton, J., J.S. Brown, J.K Summers, V.D. Engle, and P.E. Bourgeois. 1998. Alabama Monitoring & Assessment Program – Coastal. ALAMAP – Coastal. A Report on the Condition of the Estuaries of Alabama in 1993-1995. A Program in Progress. Alabama Department of Environmental Management, Field Operations Division, Mobile Field Office, Mobile, AL. 20 pp.

Chesapeake Bay Foundation. 2007. 2007 State of the Bay. Philip Merril Environmental Center, Annapolis, MD. 11 pp.

Diaz-Ramos, S., D.L. Stevens, Jr., and A.R. Olsen. 1996. EMAP statistical methods manual, EPA/620/R-96/002. U.S. Environmental Protection Agency, Office of Research and Development, Office of Research and Development, NHEERL Western Ecology Division, Corvallis, Oregon.

Fortner, A.R., M. Sanders, and S.W. Lemire. 1996. Polynuclear aromatic hydrocarbons and trace metal burdens in sediment and the oyster, *Crassostrea virginica* (Gmelin), from two high salinity estuaries in South Carolina. In: Sustainable Development in the Southeast Coastal Zone. F.J. Vernberg, W.B. Vernberg and T. Siewicki, eds. University of South Carolina Press, Columbia, SC, USA, pp. 445-477.

Holland, A.F., D.M. Sanger, C.P. Gawle, S.B. Lerberg, M.S. Santiago, G.H.M. Riekerk, L.E. Zimmerman, and G.I. Scott. 2004. Linkages between tidal creek ecosystems and the landscape and demographic attributes of their watersheds. Journal of Experimental Marine Biology and Ecology 298: 151-178.

Hyland, J.L., R.F. Van Dolah, and T.R. Snoots. 1999. Predicting stress in benthic communities of southeastern U.S. estuaries in relation to chemical contamination of sediments. Environmental Toxicology and Chemistry 18(11): 2557-2564.

Hyland, J.L., W.L. Balthis, V.D. Engle, E.R. Long, J.F. Paul, J.K. Summers, R.F. Van Dolah. 2003. Incidence of stress in benthic communities along the US Atlantic and Gulf of Mexico coasts within different ranges of sediment contamination from chemical mixtures. Environmental Monitoring and Assessment 81: 149-161.

Hyland, J., L. Balthis, I. Karakassis, P. Magni, A. Petrov, J. Shine, O. Vestergaard, and R. Warick. 2005. Organic carbon content of sediments as an indicator of stress in marine benthos. Marine Ecology Progress Series 285: 91-103.

Joseph, E.B. 1973. Analysis of a nursery ground. In Pacheco, A.L. (ed) Proceedings of a Workshop on Egg, Larval, and Juvenile Stages of Fish in Atlantic Coast Estuaries. pp 118-121.

Krahn, M.M., C.A. Wigren, R.W. Pearce, L.K. Moore, R.G. Boger, W.D. McLeod, Jr., S.L. Chan, and D.W. Brown. 1988. New HPLC cleanup and revised extraction procedures for organic contaminants, National Oceanic and Atmospheric Administration Technical Memorandum NMFS F/NWC-153: 23-47.

Krebs, C.J. 1972. The experimental analysis of distribution and abundance. Ecology. New York: Harper and Row.

Kucklick, J.R., S. Sivertsen, M. Sanders, and G. Scott. 1997. Factors influencing polycyclic aromatic hydrocarbon concentrations and patterns in South Carolina sediments. Journal of Experimental Marine Biology and Ecology 213: 13-29.

Lerberg, S.B., A.F. Holland, and D.M. Sanger. 2000. Responses of tidal creek macrobenthic communities to the effects of watershed development. Estuaries 23: 838-853.

Little, C. 2000. The biology of soft shores and estuaries. In: Crawley, M.J., C. Little, T.R.E. Southwood, and S. Ulfstrand (eds) Biology of Habitats, series, Oxford University Press, USA. 264 pp.

Long, E.R., and L.G. Morgan. 1990. The potential for biological effects of sediment-sorbed contaminants tested in the United Status and trends Program. NOAA Technical Memorandum NOA OMA52. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Rockville, MD. 235 pp.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine estuarine sediments. Environmental Management 19: 81-97.

Long, E.R., G.I. Scott, J. Kucklick, M. Fulton, B. Thompson, R.S. Carr, K.J. Scott, G.B. Thursby, G.T. Chandler, J.W. Anderson, and G.M. Sloane. 1997. Final Report. Magnitude and extent of sediment toxicity in selected estuaries of South Carolina and Georgia. NOAA Technical Memorandum NOS ORCA: Technical Summary Report 57. 178 pp.

Mann, K.H. 1982. Ecology of coastal waters. University of California press, Los Angeles, CA. 322 pp.

Microbics Corporation. 1992. Microtox® Manual. Vol. 1. 1992 edition. Carlsbad, CA.

Nelson, D.M., E.A. Irlandi, L.R. Settle, M.E. Monaco, and L. Coston-Clements. 1991. Distribution and abundance of fishes and invertebrates in Southeast estuaries. ELMR Rep. No. 9. NOAA/NOS Strategic Environmental Assessments Division, Silver Spring, MD. 167 pp.

Partridge, V. 2007. Condition of Coastal Waters of Washington State, 2000-2003: A Statistical Summary. Washington State Department of Ecology, Olympia, WA. Publication No. 07-03-051. Available online at: www.ecy.wa.gov/biblio/0703051.html

Plumb, R.H., Jr. 1981. Procedures for handling and chemical analyses of sediment and water samples. Tech. Rept. EPA ICE-81-1 prepared by Great Lakes Laboratory, State University College at Buffalo, NY, for the U.S. Environmental Protection Agency/Corps of Engineers Technical Committee on Criteria for Dredge and Fill Material. Published by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Ringwood, A.H., M.E. DeLorenzo, P.E. Ross, and A.F. Holland. 1997. Interpretation of Microtox solid phase toxicity tests: The effects of sediment composition. Environmental Toxicology and Chemistry 16(6): 1135-1140.

Ringwood, A.H., and C.J. Keppler. 1998. Seed clam growth: An alternative sediment bioassay developed during EMAP in the Carolinian Province. Environmental Monitoring and Assessment 511: 247-257.

Sanger, D.M., A.F. Holland, and G.I. Scott. 1999a. Tidal creek and salt marsh sediments in South Carolina Coastal Estuaries. I. Distribution of trace metals. Archives of Environmental Contamination and Toxicology 37: 445-457

Sanger, D.M., A.F. Holland, and G.I. Scott. 1999b. Tidal creek and salt marsh sediments in South Carolina Coastal estuaries. II. Distribution of organic contaminants. Archives of Environmental Contamination and Toxicology 37: 458-471.

South Carolina Budget and Control Board. 2013. South Carolina Statistical Abstract website. Available online at http://abstract.sc.gov/chapter14/pop5.php

South Carolina Department of Health and Environmental Control. a. Water Classifications and Standards (Regulation 61-68) and Classified Waters (Regulation 61-69) for the State of South Carolina. Office of Environmental Quality Control, Columbia, SC.

South Carolina Department of Health and Environmental Control. b. Procedures and Quality Control Manual for Chemistry Laboratories. Bureau of Environmental Services, Columbia, S.C.

South Carolina Department of Health and Environmental Control. c. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Office of Environmental Quality Control, Columbia, SC.

South Carolina Department of Health and Environmental Control. d. Laboratory Procedures Manual for Environmental Microbiology. Bureau of Environmental Services, Columbia, S.C.

Stevens, D.L. 1997. Variable density gridbased sampling designs for continuous spatial populations. Envirometrics 8: 167-195.

Stevens, D.L., and A.R. Olsen. 1999. Spatially restricted surveys over time for aquatic resources. Journal of Agricultural, Biological and Environmental Statistics 4: 415-428.

U.S. Environmental Protection Agency. 2001. National Coastal Condition Report. EPA-620-R-01-005. 204 pp.

U.S. Environmental Protection Agency. 2004. National Coastal Condition Report II. EPA-620-R-03-002. 286 pp.

U.S. Environmental Protection Agency. 2006. National Coastal Condition Report. EPA-842B-06/001. 445 pp.

Van Dolah, R.F., J.L. Hyland, A.F. Holland, J.S. Rosen, and T.R. Snoots. 1999. A benthic index of biological integrity for assessing habitat quality in estuaries of the southeastern United States. Marine Environmental Research 48: 269-283.

Van Dolah, R.F., D.E. Chestnut and G.I. Scott. 2000. A baseline assessment of environmental and biological conditions in Broad Creek and the Okatee River, Beaufort County, South Carolina. Final Report to Beaufort County Council. 281 pp.

Van Dolah, R.F., P.C. Jutte, G.H.M. Riekerk, M.V. Levisen, L.E. Zimmernman, J.D. Jones, A.J.Lewitus, D.E. Chestnut, W. McDermott, D. Bearden, G.I. Scott, and M.H. Fulton. 2002. The Condition of South Carolina's Estuarine and Coastal Habitats During 1999-2000: Technical Report. Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 90. 132 pp.

Van Dolah, R.F., P.C. Jutte, G.H.M. Riekerk, M.V. Levisen, L.E. Zimmernman, J.D. Jones, A.J. Lewitus, D.E. Chestnut, W. McDermott, D. Bearden, G.I. Scott, and M.H. Fulton. 2004. The Condition of South Carolina's Estuarine and Coastal Habitats During 2001-2002: Technical Report. Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 100. 70 pp.

Van Dolah, R.F., D.C. Bergquist, G.H.M. Riekerk, M.V. Levisen, S.E. Crowe, S.B. Wilde, D.E. Chestnut, W. McDermott, M.H. Fulton, E. Wirth, and J. Harvey. 2006. The Condition of South Carolina's Estuarine and Coastal Habitats During 2003-2004: Technical Report. Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 101. 70 pp.

Appendix 1. Summary of station locations and dates sampled in 2009 and 2010 . Open water stations have the prefix "RO" and tidal creek stations have the prefix "RT".

SCECAP 2009
Station Information - Open Water

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RO09359	Open	32.58776	80.21810	11.3	8/5/2009	Charleston	NDV	North Edisto River across from Point of Pines
RO09360	Open	33.17524	79.28732	2.7	7/15/2009	Georgetown	NDV	North Santee River in the ICWW near Crow Island
RO09361	Open	32.33160	80.75273	4.6	7/21/2009	Beaufort	R<1	Broad River about mid way down Daws Island
RO09362	Open	32.47430	80.54867	3.5	7/28/2009	Beaufort	R>1	West of Morgan Island between Coosaw and Morgan Rivers
RO09363	Open	32.79151	79.97076	7.6	8/11/2009	Charleston	I>1	Ashley River just below the Citadel Military College
RO09364	Open	33.34444	79.26373	1.5	7/15/2009	Georgetown	I>1	Winyah Bay northeast of Hare Island
RO09366	Open	32.28147	80.70106	9.4	7/29/2009	Beaufort	R>1	St Helena Sound south of Parris Island
RO09367	Open	32.53297	80.57851	5.8	7/28/2009	Beaufort	NDV	Bull River near the mouth of Wimbee Creek
RO09368	Open	32.79369	79.92544	5.2	8/12/2009	Charleston	I<1	Cooper River at the southern end of Town Creek
RO09369	Open	32.14990	80.85226	4.3	7/22/2009	Beaufort	R>1	Cooper River North of Daufuskie Island
RO09370	Open	32.39547	80.78335	11.3	7/21/2009	Beaufort	R>1	Broad River just north of the SC170 bridge
RO09371	Open	32.45694	80.44892	4.9	8/4/2009	Beaufort	NDV	St. Helena Sound East of Morgan Island
RO09372	Open	32.94911	79.91803	5.5	8/11/2009	Berkeley	I>1	Cooper River just inside Flagg Creek
RO09373	Open	32.48880	80.82304	3.0	7/21/2009	Jasper	R<1	Broad River across from the Whale Branch
RO09374	Open	32.29050	80.57900	7.6	7/29/2009	Beaufort	R>1	Trenchards Inlet across from Moon Creek
NOR09056	Open	32.83802	79.94730	5.8	8/11/2009	Charleston	I<1	Cooper River in the turning basin of Shipyard Creek

* Development codes: NDV = no development visible, R<1 = residential less than 1 km away, R>1 = residential greater than 1 km away, I<1 = industrial site less than 1 km away, I>1 = industrial site located greater than 1 km away. Stations starting with R are random sites and N are non-random sites.

SCECAP 2009
Station Information - Tidal Creek

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RT09090	Creek	32.61712	80.68250	1.2	7/28/2009	Beaufort	NDV	Wimbee Creek near the Combahee River
RT09091	Creek	32.55690	80.21660	1.0	8/5/2009	Charleston	NDV	South Creek at Botany Bay Island
RT09092	Creek	32.87867	79.66976	2.3	8/12/2009	Charleston	NDV	Price Creek in a tributary called Schooner Creek
RT09094	Creek	32.47528	80.61646	3.9	7/28/2009	Beaufort	R<1	Lucy Point Creek west of Coosaw Island
RT09098	Creek	32.28956	80.56301	5.6	7/29/2009	Beaufort	NDV	Trenchards Inlet in Moon Creek
RT09099	Creek	32.40449	80.46832	2.7	8/4/2009	Beaufort	NDV	Harbor River in Wards Creek
RT09100	Creek	32.68759	79.90057	2.4	8/11/2009	Charleston	R>1	Lighthouse Creek towards Folly River
RT09101	Creek	32.55720	80.89444	2.4	7/21/2009	Jasper	NDV	Broad River in the Coosawhatchie River
RT09103	Creek	32.55630	80.35126	3.7	8/4/2009	Charleston	R<1	Bailey Creek in the ACE Basin
RT09105	Creek	32.26033	80.79330	2.1	7/22/2009	Beaufort	R<1	Mackay Creek west of Pinckney Island
RT09108	Creek	32.91291	79.64095	2.7	8/12/2009	Charleston	R>1	Bull Creek south of Sewee Bay
RT09110	Creek	32.48610	80.53845	2.7	8/4/2009	Beaufort	R>1	Morgan Island in Bass Creek
RT09111	Creek	32.70542	80.07915	2.7	8/5/2009	Charleston	R>1	Bohicket Creek near Maybank Hwy
RT09113	Creek	33.57055	79.01477	1.0	7/14/2009	Georgetown	R<1	Murrell's Inlet in the north end
RT09114	Creek	32.31788	80.51867	4.6	7/29/2009	Beaufort	NDV	Pritchards Island in Skull Creek
NTR09017	Creek	32.82438	79.86722	1.5	8/12/2009	Charleston	R<1	Hobcaw Creek in Wando River, repeat of station RT99017
NTR09153	Creek	32.30614	80.92765	1.5	7/22/2009	Beaufort	R<1	Upper Okatie River, repeat of RT022153
NTR09181	Creek	32.22173	80.92003	2.1	7/22/2009	Beaufort	R<1	May River south of Rose Dhu Creek, repeat of RT032181

* Development codes: NDV = no development visible, R<1 = residential less than 1 km away, R>1 = residential greater than 1 km away, I<1 = industrial site less than 1 km away, I>1 = industrial site located greater than 1 km away. Stations starting with R are random sites and N are non-random sites.

SCECAP 2010
Station Information - Open Water

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RO10375	Open	32.52394	80.35958	4.3	7/21/2010	Charleston	NDV	St Pierre Creek in the ACE Basin
RO10376	Open	32.93638	79.62708	5.5	8/4/2010	Charleston	R>1	Bulls Bay in Anderson Creek
RO10377	Open	32.19968	80.79745	4.0	8/11/2010	Beaufort	R>1	May River south of Bass Creek
RO10378	Open	32.50248	80.64027	2.1	8/18/2010	Beaufort	R<1	Coosaw River just north of Lady's Island
RO10379	Open	32.66930	80.12375	3.7	7/20/2010	Charleston	R<1	Bohicket Creek upstream of Camp Ho Non Wah
RO10380	Open	33.28366	79.26726	1.8	8/3/2010	Georgetown	I>1	Winyah Bay just north of the Middle Ground
RO10382	Open	32.29031	80.70082	4.9	8/10/2010	Beaufort	R>1	St Helena Sound just south of Parris Island
RO10383	Open	32.54392	80.54202	5.5	7/27/2010	Colleton	NDV	Combahee River south of the Old Chehaw River
RO10385	Open	32.31814	80.87542	2.7	8/10/2010	Beaufort	R>1	Colleton River west of Callawassie Island
RO10387	Open	32.50706	80.44339	4.0	7/27/2010	Colleton	NDV	Two Sisters Creek near the mouth
RO10388	Open	32.88671	79.87637	2.4	7/14/2010	Berkeley	R>1	Wando River in Beresford Creek
RO10389	Open	32.54809	80.83512	1.2	8/17/2010	Beaufort	R>1	Pocotaligo River near Halls Island
RO10390	Open	32.42197	80.57256	1.8	7/28/2010	Beaufort	R<1	Morgan River in Jenkins Creek at tip of Polawana Island
RO10391	Open	32.60892	80.29443	1.8	7/20/2010	Charleston	R>1	Steamboat Creek near Steamboat Landing
RO10392	Open	33.04564	79.41651	4.9	8/3/2010	Charleston	NDV	Cape Romain just south of Muddy Bay

* Development codes: NDV = no development visible, R<1 = residential less than 1 km away, R>1 = residential greater than 1 km away, I<1 = industrial site less than 1 km away, I>1 = industrial site located greater than 1 km away.

SCECAP 2010
Station Information - Tidal Creek

Station	Station Type	Latitude Decimal Degrees	Longitude Decimal Degrees	Station Depth (meters)	Date Sampled	County	Development Code*	Approximate Location
RT10115	Creek	32.37324	80.46038	1.8	7/28/2010	Beaufort	NDV	Johnson Creek behind Hunting Island
RT10116	Creek	32.78719	79.88676	2.7	8/4/2010	Charleston	R<1	Charleston Harbor in the mouth of Shem Creek
RT10119	Creek	32.52266	80.34808	2.4	7/21/2010	Colleton	R>1	South Edisto River in Big Bay Creek
RT10121	Creek	32.32629	80.83422	2.1	8/10/2010	Beaufort	R>1	Colleton River in Callawassie Creek
RT10123	Creek	32.70169	80.27625	1.2	7/20/2010	Charleston	R<1	North Edisto River in Toogoodoo Creek
RT10124	Creek	32.92377	79.61502	0.9	8/4/2010	Charleston	NDV	Bulls Bay in Bull Creek
RT10126	Creek	32.57666	80.62802	1.2	8/18/2010	Beaufort	NDV	Schooner Channel east of Wimbee Creek
RT10127	Creek	32.64669	79.99370	2.4	7/13/2010	Charleston	R>1	Stono River in Green Creek
RT10129	Creek	33.19025	79.29234	2.7	8/3/2010	Georgetown	NDV	North Santee River in Minim Creek
RT10131	Creek	32.57909	80.53391	7.6	7/27/2010	Colleton	NDV	Chehaw River west of Big Island
RT10132	Creek	32.80049	79.98340	2.7	7/14/2010	Charleston	R<1	Oldtown Creek at Charles Towne Landing
RT10133	Creek	32.12564	80.99716	5.5	8/11/2010	Jasper	I>1	Wright River near Turn Bridge landing
RT10137	Creek	32.20354	80.85822	1.8	8/11/2010	Beaufort	R>1	May River south of Potato Island
RT10138	Creek	32.59871	80.83522	0.9	8/17/2010	Jasper	R>1	Pocotaligo River west of Oak Grove Plantation
RT10139	Creek	32.62321	80.32430	2.0	7/21/2010	Charleston	NDV	Steamboat Creek in Whooping Island Creek

* Development codes: NDV = no development visible, R<1 = residential less than 1 km away, R>1 = residential greater than 1 km away, I<1 = industrial site less than 1 km away, I>1 = industrial site located greater than 1 km away

Appendix 2. Summary of the criteria and amount of open water and tidal creek habitat scoring as good, fair or poor for each SCECAP parameter and index for the 2009-2010 survey period.

Parameter	Criteria			Percent of Open Water Habitat			Percent of Tidal Creek Habitat		
WATER QUALITY	**Good**	**Fair**	**Poor**	**Good**	**Fair**	**Poor**	**Good**	**Fair**	**Poor**
Water Quality Index				97	3	0	80	13	7
Dissolved Oxygen (mg/L)	≥ 4	≥ 3 & < 4	< 3	87	10	0	57	37	6
pH (salinity corrected)	> 7.35	> 7.22 & ≤ 7.35	≤ 7.22	90	10	0	67	23	10
Fecal Coliform	≤ 43	> 43 & ≤ 400	> 400	90	10	0	90	10	0
Eutrophication Score				90	7	3	77	20	3
Total Nitrogen	≤ 0.81	> 0.81 & ≤ 1.05	> 1.05	97	3	0	93	3	0*
Total Phosphorus	≤ 0.10	> 0.10 & ≤ 0.12	> 0.12	83	7	10	80	13	7
Chlorophyll a	≤ 11.5	> 11.5 & ≤ 16.4	> 16.4	83	17	0	70	13	17
SEDIMENT QUALITY									
Sediment Quality index				83	7	10	80	13	7
Contaminants ERMQ	≤ 0.020	> 0.020 & ≤ 0.058	> 0.058	74	23	3	77	17	6
Toxicity	< 1	≥ 1 & < 2	≥ 2	74	23	3	67	27	6
TOC	< 3	≥ 3 & ≤ 5	> 5	90	3	7	90	7	3
BIOLOGICAL CONDITION									
Benthic IBI	≥ 3	≥ 2 & < 3	< 2	84	13	3	74	23	3
HABITAT QUALITY									
Habitat Quality Index				87	10	3	73	27	0

* Data for one station was missing which results in no score for the area it represented.

Appendix 3. Summary of the Water Quality, Sediment Quality, Biological Condition, and Habitat Quality Index scores and their component measure scores by station for 2009 and 2010. Green represents good condition, yellow represent fair condition, and red represents poor condition. The actual Habitat Quality Index score is shown to allow the reader to see where the values fall within the above general coding criteria. See text for further details on the ranges of values representing good, fair, and poor for each measure and index score.

Station	Water Quality								Sediment Quality				Biological Condition	Habitat Quality	County	Location
	Dissolved Oxygen	Fecal Coliform	pH	Total Nitrogen	Total Phosphorus	Chlorophyll a	Eutrophic Index	Water Quality Index	Toxicity	Sediment TOC	Contaminants	Sediment Quality Index	Biological Index (B-IBI)	Habitat Quality Index		
RO09374							5	5				5	5	5.0	Beaufort	Trenchards Inlet across from Moon Creek
RO09373							5	5				5	5	5.0	Jasper	Broad River across from the Whale Branch
RO09372							5	5				0	0	1.7	Berkeley	Cooper river just inside Flagg Creek
RO09371							3	5				5	5	5.0	Beaufort	St. Helena Sound East of Morgan Island
RO09370							5	5				5	5	5.0	Beaufort	Broad River just north of the SC170 bridge
RO09369							5	5				5	5	5.0	Beaufort	Cooper River North of Daufuskie Island
RO09368							5	5				5	5	5.0	Charleston	Cooper River at the southern end of Town Creek
RO09367							5	5				5	5	5.0	Beaufort	Bull River near the mouth of Wimbee Creek
RO09366							5	5				5	5	5.0	Beaufort	St Helena Sound south of Parris Island
RO09364							5	5				5	5	5.0	Georgetown	Winyah Bay northeast of Hare Island
RO09363							5	5				0	3	2.7	Charleston	Ashley River just below the Citadel Military College
RO09362							5	5				5	5	5.0	Beaufort	West of Morgan Island between Coosaw and Morgan Rivers
RO09361							5	5				5	5	5.0	Beaufort	Broad River about mid way down Daws Island
RO09360							5	5				0	3	2.7	Georgetown	North Santee River in the ICWW near Crow Island
RO09359							5	5				5	3	4.3	Charleston	North Edisto River across from Point of Pines
RT09114							5	5				5	5	5.0	Beaufort	Pritchards Island in Skull Creek
RT09113							5	5				5	5	5.0	Georgetown	Murrell's inlet in the north end
RT09111							5	5				5	5	5.0	Charleston	Bohicket Creek near Maybank Hwy
RT09110							5	5				5	5	5.0	Beaufort	Morgan Island in Bass Creek
RT09108							5	5				5	5	5.0	Charleston	Bull Creek south of Sewee Bay
RT09105							5	5				5	5	5.0	Beaufort	Mackay Creek west of Pinckney Island
RT09103							3	5				5	5	5.0	Charleston	Bailey Creek in the ACE Basin
RT09101							5	5				5	5	5.0	Jasper	Broad River in the Coosawhatchie River
RT09100							5	5				5	5	5.0	Charleston	Lighthouse Creek towards Folly River
RT09099							5	5				5	5	5.0	Beaufort	Harbor River in Wards Creek
RT09098							5	5				5	5	5.0	Beaufort	Trenchards Inlet in Moon Creek
RT09094							5	5				3	3	3.7	Beaufort	Lucy Point Creek west of Coosaw Island
RT09092							5	5				5	5	5.0	Charleston	Price Creek in a tributary called Schooner Creek
RT09091							0	3				5	5	4.3	Charleston	South Creek at Botany Bay Island
RT09090							5	5				5	5	5.0	Beaufort	Wimbee Creek near the Combahee River
NOR09056							5	5				0	3	2.7	Charleston	Cooper River in the turning basin of Shipyard Creek
NTR09181							5	5				5	5	5.0	Beaufort	May River south of Rose Dhu Creek, repeat of RT032181
NTR09153							5	5				5	3	4.3	Beaufort	Upper Okatie River, repeat of RT022153
NTR09017							3	5				5	3	4.3	Charleston	Hobcaw Creek in Wando River, repeat of station RT99017

Station	Water Quality								Sediment Quality				Biological Condition	Habitat Quality	County	Location
	Dissolved Oxygen	Fecal Coliform	pH	Total Nitrogen	Total Phosphorus	Chlorophyll a	Eutrophic Index	Water Quality Index	Toxicity	Sediment TOC	Contaminants	Sediment Quality Index	Biological Index (B-IBI)	Habitat Quality Index		
RO10392							3	5				3	5	4.3	Charleston	Cape Romain just south of Muddy Bay
RO10391							5	5				5	5	5.0	Charleston	Steamboat Creek near Steamboat Landing
RO10390							5	5				5	5	5.0	Beaufort	Morgan River in Jenkins Creek at tip of Polawana Island
RO10389							5	5				5	5	5.0	Beaufort	Pocotaligo River near Halls Island
RO10388							5	5				5	5	5.0	Berkeley	Wando River in Beresford Creek
RO10387							5	5				5	5	5.0	Colleton	Two Sisters Creek near the mouth
RO10385							5	5				5	5	5.0	Beaufort	Colleton River west of Callawassie Island
RO10383							0	3				5	5	4.3	Colleton	Combahee River south of the Old Chehaw River
RO10382							5	5				5	5	5.0	Beaufort	St Helena Sound just south of Parris Island
RO10380							5	5				3	3	3.7	Georgetown	Winyah Bay just north of the Middle Ground
RO10379							5	5				5	5	5.0	Charleston	Bohicket Creek upstream of Camp Ho Non Wah
RO10378							5	5				5	5	5.0	Beaufort	Coosaw River just north of Lady's Island
RO10377							5	5				5	5	5.0	Beaufort	May River south of Bass Creek
RO10376							5	5				5	5	5.0	Charleston	Bulls Bay in Anderson Creek
RO10375							5	5				5	5	5.0	Charleston	St Pierre Creek in the ACE Basin
RT10139							3	5				5	5	5.0	Charleston	Steamboat Creek in Whooping Island Creek
RT10138							5	0				5	3	2.7	Jasper	Pocotaligo River west of Oak Grove Plantation
RT10137							5	5				3	5	4.3	Beaufort	May River south of Potato Island
RT10133							5	3				5	5	4.3	Jasper	Wright River near Turn Bridge landing
RT10132							5	3				3	3	3.0	Charleston	Oldtown Creek at Charles Towne Landing
RT10131							5	5				5	0	3.3	Colleton	Chehaw River west of Big Island
RT10129							3	5				0	3	2.7	Georgetown	North Santee River in Minim Creek
RT10127							5	5				5	5	5.0	Charleston	Stono River in Green Creek
RT10126							3	0				5	3	2.7	Beaufort	Schooner Channel east of Wimbee Creek
RT10124							3	3				3	5	3.7	Charleston	Bulls Bay in Bull Creek
RT10123							0	3				5	3	3.7	Charleston	North Edisto River in Toogoodoo Creek
RT10121							5	5				5	5	5.0	Beaufort	Colleton River in Callawassie Creek
RT10119							5	5				5	5	5.0	Colleton	South Edisto River in Big Bay Creek
RT10116							5	5				0	5	3.3	Charleston	Charleston Harbor in the mouth of Shem Creek
RT10115							5	5				5	3	4.3	Beaufort	Johnson Creek behind Hunting Island


SLOW